MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXVI NOVEMBER–DECEMBER, 1934 NO. 6

DASYSCYPHAE ON CONIFERS IN NORTH AMERICA. III. DASYSCYPHA PINI

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(WITH PLATES 52 AND 53)

INTRODUCTION

In the first two papers of this series the authors discussed the taxonomy of the European larch canker parasite, *Dasyscypha Willkommii* (Hartig) Rehm (**4**), introduced into the United States upon imported larch, and the native fungus, *D. Ellisiana* (Rehm) Sacc. (**5**), a commonly occurring native saprophyte upon species of pine and other conifers. The latter fungus has become parasitic upon introduced Douglas fir and pine species in New England and elsewhere along the Atlantic seaboard. The present paper is concerned with a very interesting highland Discomycete with brown exciple, *parasitic* upon five-needled and Scotch pines, occurring at high altitudes and in north latitudes in North America and Scandinavia. This parasite heretofore has been regarded generally as synonymous with the *saprophytic*, brown-excipled species, *Dasyscypha fuscosanguinea* Rehm (**13**), of central Europe. Certain mycologists have been inclined to question the identity of the parasitic organism with Rehm's fungus growing on pines in the Alps. Morphological differences had been noted between the two, but these were not considered sufficient to warrant specific rank for the former organism (**15**).

Survey work in the Lake States and in the Pacific Northwest,

[MYCOLOGIA for September–October (**26**: 379–477) was issued October 1, 1934]

both in the United States and Canada, which has been concerned with the distribution and spread of white pine blister rust in the West, produced some very interesting collections of a conspicuous pine canker, somewhat similar to that caused by white pine blister rust (**6**, **15**) and very much like that caused by *Dasyscypha Willkommii*, upon native five-needled pines—*Pinus Strobus* L., *P. monticola* D. Don and *P. albicaulis* Engel. Invariably these resinous lesions were closely associated with apothecia, covered with brownish hairs, whose discs were a brilliant orange-yellow. Because of their exceptional size and beauty they made the malignant lesions upon which they fruited abundantly, very striking, particularly in damp weather.

The morphological characters of this North American *Dasyscypha* parasite, associated with a destructive pine canker, were very much like those given by Brunchorst (**1**), Lagerberg (**11**), and Jørstad (**7**) for a Scandinavian fungus causing a similar canker in the Arctic Circle regions. The investigation has shown that the North American parasite is practically identical with the Scandinavian *Dasyscypha* form on *Pinus sylvestris* L. Morphological as well as physiological data are given substantiating the specific rank accorded this highland pathogen of northern latitudes in Europe and in America.

HISTORY

Lagerberg (**11**), in a comprehensive paper discussing a canker and parasite of *Pinus sylvestris* growing in the pine barrens of northern latitudes in Scandinavia, pointed out that Brunchorst (**1**, p. 9) was the first author to draw attention to the parasitic nature of a brown-excipled *Dasyscypha*. Lagerberg called the pathogen *D. fuscosanguinea*.

Previously in 1892 the Norwegian mycologist had described the parasite as *Lachnella Pini* n. sp. and had given not only an excellent description of the fungus but also an adequate account of the disease (**1**, FIG. 3; PL. without number or legend). Brunchorst's name for the highland parasite would probably have been recognized by Lagerberg and other pathologists and mycologists but for the fact that Karsten (**10**) had maintained that the pine pathogen in Norway was synonymous with Rehm's saprophytic

species, *Dasyscypha fuscosanguinea* (**12**, **13**), from the Tyrolese Alps. Apparently there has been a general acceptance of Karsten's opinion and the organism described by Brunchorst has been regarded as identical with Rehm's brown, hairy-cup fungus.

In 1881, when Rehm first described *Dasyscypha fuscosanguinea* (**12**), which he later characterized as a "Hochalpenbewohner" (**13**), he considered his fungus as occurring saprophytically on dead branches of *Pinus Cembra* L. and *P. pumilio* Haenke. It is notable that in his seond description (**13**, p. 848) where a synonomy is given, Brunchorst's *Lachnella Pini* is not listed, but in the addenda at the end of the volume (**13**, p. 1268) he cited Brunchorst's fungus as synonymous with his species, following Karsten. In his discussion Rehm (**13**, p. 849) questioned Karsten's new combination *Lachnella fuscosanguinea* (Rehm) for a Finnish fungus on dead branches of *Pinus sylvestris*. There was reason for this doubt because Karsten (**9**) apparently was concerned with another fungus—a large-spored, white-excipled form related to Hartig's *Dasyscypha* (*Peziza*) *Willkommii*. Karsten (**10**) apparently receded from his former judgment, for in 1895 he reverted to Rehm's usage of *Dasyscypha* for the Tyrolese species. In view of Karsten's confused thinking with regard to the identity of both Rehm's and Brunchorst's species, it is unfortunate that his opinion should have had weight.

Among Rehm's personal herbarium specimens of *Dasyscypha fuscosanguinea,* now preserved at the Botanical Museum, Stockholm, is included the pine parasite collected by Lagerberg (**11**) in 1911 in northern Sweden, 65° n. lat., and determined by him as *D. fuscosanguinea*. Rehm had distributed this specimen as Ascomyceten *112c*. *Dasyscypha fuscosanguinea* Rehm, without annotation or particular comment. The inclusion of this fungus, which apparently Lagerberg regarded as identical with Brunchorst's parasite, among specimens determined by Rehm as his own species, came after that German author had published his final description. Apparently Rehm himself was not cognizant of morphological differences or the parasitic nature of the Arctic fungus. Since the time of Rehm, the northern European parasite has been accepted as synonymous with *D. fuscosanguinea* even in

Scandinavia where the organism has been known for a long time and where it has been studied most.

Recently in 1929, Stillinger, reported a *Dasyscypha* species from North America with brownish excipular hairs and orange-yellow disc as *D. fuscosanguinea* (**15**), which he described as a parasite of western white pine (*Pinus monticola*). This fungus was probably first collected in August, 1922, along the western edge of Glacier National Park in Montana. In 1925, Dr. J. S. Boyce, who had become interested in the pathogen, sent specimens to Dearness for determination. The Canadian mycologist, who was the first to publish on the organism in this country, recognized a great similarity between the Idaho parasite and the so-called *D. fuscosanguinea* of Lagerberg from northern Sweden, but he was inclined to question the identity of the parasite with Rehm's saprophyte occurring in the Tirol. Recognizing morphological as well as physiological differences, he (**2**) commented as follows upon northern Idaho material, parasitic on *P. monticola,* collected in 1924 by Boyce: "(?) *Dasyscypha fuscosanguinea* Rehm. . . . This compared with material collected by Lagerberg on *P. silvestris* in Sweden, labeled as above and passed upon by Rehm, is paler externally, more luteous on the disc and has longer paraphyses, *but on the whole it is very similar.* It is hardly sanguineous and if it is the same species as the European one it must be much more destructive by inference from Rehm's statement of habitat, 'an durren Aestchen'—on dry branchlets."

When Stillinger (**15**) published his interesting paper on *Dasyscypha fuscosanguinea,* he expressed the opinion, concurred in independently by J. R. Weir, W. W. Diehl and Dearness, that the North American fungus could very properly be recognized as the parasitic form of *D. fuscosanguinea.* Stillinger cited differences in sizes of asci and spores between the American parasite and Rehm's fungus as given in the original description. Apparently a comparison was not made with Lagerberg's parasitic material that Dearness (**2**) had examined and reported upon.

The authors were greatly impressed by the fact that specimens of the highland parasite were always to be found in direct association with pronounced cankers. This fungus apparently did not occur saprophytically as did *D. fuscosanguinea.* The life

habits of these two organisms were similar to those previously discussed (**4**) for the parasite, *D. Willkommii* and the nearly related, but in this case, closely associated saprophyte, *D. calycina* Fuckel (nec *Peziza calycina* Schum. and *P. calycina* Fries). An examination of his personal specimens of *D. fuscosanguinea,* which had been carefully annotated by Rehm, and a comparison of these with herbarium and fresh European and North American material of the highland parasite, convinced the writers of the separate identity of the two organisms.

EXAMINATION OF DASYSCYPHA FUSCOSANGUINEA SPECIMENS IN REHM'S PERSONAL HERBARIUM

To those unaware of Rehm's method of recording observations on the Discomycetes which he reported, it may be of interest here to note that the great German mycologist carefully recorded the measurements of spores, asci, paraphyses and hairs with supplementary descriptive detail in fine German script, upon small pieces of note paper attached to the specimen packet. Upon bits of coördinate paper pasted to these, he delineated the typical shape and size of spores in the material studied. Most of the *D. fuscosanguinea* specimens were so annotated. Accordingly we were able to examine probably the actual specimens Rehm had studied when he wrote the descriptions for his species.

A study of his personal collections of *Dasyscypha fuscosanguinea* showed that at least two morphologically distinct groups of brown-excipled forms were involved, one, saprophytic on cones and dead twigs and branches of *Pinus pumilio, P. Cembra, P. montana* Mill. and *P. Mugho* Poir., having shorter spores and asci than those of a second group, represented by a single unannotated specimen collected in northern Sweden on *Pinus sylvestris* by Lagerberg. *The fungus collected by Lagerberg was the only one indicating a parasitic habit by the production of a canker.* The packet enclosing this specimen contained the Swedish label: " Flora Suecica. *Dasyscypha fuscosanguinea* Rehm. Prov. Vasterbotten, Staatforst Östra Jörnsmarken, Juli, 1911. Kiefernheide, 65° n. Breite, legit. T. Lagerberg." It should be noted that Rehm in distributing this collection as Ascomceten *112c D. fuscosanguinea* Rehm, had previously assigned this number to " *112c Dasyscypha*

fuscosanguinea Rehm var. *aurantiaca* v. Höhnel," collected in 1904 by von Höhnel, which he (Rehm), according to his herbarium notes, apparently regarded as synonymous with his own species.

Because of the evident morphologic differences alluded to in the foregoing, between the saphophytic and parasitic organisms, the authors are of the opinion that these two fungi are distinct species and have given the following amended descriptions of *Dasyscypha fuscosanguinea* and the Scandinavian pathogen, of Scotch pine. Although they have not seen Brunchorst's original specimen, a study of Scandinavian material which showed agreement with his description of the type and the canker disease associated with the organism (**1**), assured the authors that they very probably were concerned with Brunchorst's species. Accordingly they have reaffirmed the specific identity of his fungus and have made a new combination (listed below) to designate the highland parasite. Morphological observations, which agreed with those made by Lagerberg (**11**), Dearness (**2**) and Stillinger (**15**), indicated differences in color, in the size of spores, asci and paraphyses, and in the shape of the hairs and paraphyses.

DESCRIPTIONS OF THE LARGE-SPORED, BROWN-EXCIPLED DASYSCYPHAE

DASYSCYPHA FUSCOSANGUINEA Rehm, desc. emend.; Ascom. *112* nomen nudum 1872; Ber. Nat. Ver. Augsburg **26**: 30. 1881; Sacc. Syll. Fung. **8**: 459–460. 1889; Rabenh. Krypt.-Fl. 1^3: 848–849. 1896.

nec. *Lachnella fuscosanguinea* (Rehm) Karst. (Symb. Myc. Fenn. **24**: 16. 1888); *L. Pini* Brunchorst (Karsten, Hedwigia **34**: 8. 1895).

Syn: *D. fuscosanguinea* var. *aurantiaca* v. Höhn. apud Rehm (Ann. Myc. **3**: 230. 1905); (?) *Trichopeziza fuscosanguinea* Lambotte (Myc. Belg. **1**: 294. 1887).[1]

Apothecia separate or aggregate, sparse or moderately abundant, waxy, leathery, distinctly stalked, at first globose, urn-shaped, ex-

[1] Rehm (**13**) was inclined to doubt that *Lachnella confusa* Karst., on Scotch pine from Finland, listed in the synonomy of *Dasyscypha fuscosan-*

panding as a flat disc, hymenium "blood-red" to "reddish-yellow" (**12**, **13**) when dry; exciple (dry) covered with Buckthorn brown, Dresden brown to cinnamon-brown [2] hairs ("dark brown" according to Rehm); cups 2–6 mm. diam., commonly 2–4 mm. diam., stalk about 1 mm. long; when dry the exciple folds lengthwise against itself, concealing the disc which with age becomes ochraceous, or in large apothecia, the folding may occur from three places on the margin; hairs, simple, elongate, septate with short cells, exceedingly scabrous with minute roughenings, microscopically brownish-olive, cylindrical, broadly tapering in some, with blunt apices, obtusely rounded or subacute, 3–4 μ wide; asci cylindric, clavate, extreme range, (40) 70.0–90.8 $\times$ 7.2–10.6 μ; ascospores, 8 in ascus, uniseriate or biseriate, hyaline, straight, unicellular, becoming uniseptate upon germination, ovate, elliptic or elliptic-ovate with blunt, obtusely rounded extremities, extreme range, (180) 10.6–16.0 $\times$ 4.0–6.2 μ, commonly, 12–14 $\times$ 4–5 μ; paraphyses filamentous, filiform, outranking asci, septate, with yellowish oil drops, 1.5–2 μ broad, unswollen at the apex or very slightly swollen above, apices 3 μ broad.

Imperfect stage not observed. This species has not been grown in pure culture and it may as in the case of *D. arida* (Phill.) Sacc., which has been found to produce the imperfect stage readily in culture, do likewise.

Hab. A saprophytic highland fungus of the Tirol. Occurring on bark of dead branches: *Pinus Cembra*, Kühtei, (Oetz) Tirol (c. 6200′), coll. Rehm; *P. pumilio*, Arlberg, (c. 5900′), and Peischlkopf, Tirol, (c. 5900′), coll. Britzelmayr; *P. montana*, Rudolfshütte, Stubachthal (Salzburg), coll. von Höhnel. On cone scales of *P. pumilio*, Algäu, Alps, coll. K. Arnold, and *P. Mugho*.

Dasyscypha fuscosanguinea is not known to occur in Scandinavia. Whether it occurs in North America is problematical. It

guinea was identical with his own species. We have examined the "Originalexemplar" of *L. confusa* alluded to by Rehm in his discussion (**13**, p. 849). The specimen now consists of merely a slender Scotch pine twig entirely lacking in apothecia. Accordingly we are not in position to give the characteristics of the fungus, and only can state that a canker was not present in the specimen.

[2] The color nomenclature is that of R. Ridgway, Color standards and color nomenclature. Washington, D. C. 1912.

is distinct from the shorter-spored, brown-excipled, saprophytic species, *D. arida,* first collected by Harkness on pine bark in the Sierra Nevada Mts., California, in 1876 (Grevillea **5**: 117, PL. 89, FIG. 13. 1877) and widely distributed in western North America. Whether *D. flavovirens* Bres. (Fungi Tridentini **1**: 92, PL. 104, FIG. 1. 1887) collected on *Larix europaea* in the Alps (Ortler, Eifischthal and Kals) is distinct from *D. fuscosanguinea* will be discussed in a later paper of this series.

Exsiccata examined from Rehm's personal herbarium:

"*112. Dasyscypha fuscosanguinea,* mihi nov. spec. ad interim. An abgehauenen Aesten von *Pinus Cembra* bei Kühtei (Oetz) in Tyrol c. 6200' 8/1872. Dr. Rehm." Rehm recorded ovate-elliptic spores observed in this specimen as being 12–15 × 4–5 μ; asci, 70 × 9–10 μ; paraphyses filamentous and swollen at the tip. A measurement of spores from this collection gave the following extreme range, (100) 10–16 × 4–6 μ, commonly 12–14 × 4–5 μ; asci (10) 68.6–79.4 × 8.0–10.6 μ. Although scant in number, the ascocarps, which occurred saprophytically, were in excellent condition.

"*112b. Dasyscypha fuscosanguinea* Rehm. Auf dürren Aesten von *Pinus pumilio* über dem Maiensee auf dem Arlberg in Tyrol c. 1800 m. 8/1879. Britzelmayr." Rehm annotated this specimen: ovate spores, 12–14 × 4–5 μ; "1½ reihig"; asci, 75 × 9 μ. A slide made from the identical specimen examined by Rehm (indicated by a bit of paper) showed spores with extreme range, (20) 11.0–14.2 × 4.2–6.2 μ; asci, (10) 72.2–91.6 × 7.2–10.4 μ.

"*112c. Dasyscypha fuscosanguinea* Rehm var. *aurantiaca* v. Höhn. An Rinde von *Pinus montana.* Rudolfshütte im Stubachthal (Salzburg) 8/1904. Dr. v. Höhnel." Rehm annotated this specimen: "= Rehm Discomyc"; spores, elliptic-ovate, 10–12 × 4–5 μ; asci, 60–100 μ. This is a particularly fine specimen, splendidly preserved and showing abundant, large ascocarps occurring saprophytically. Measurements of spores, extreme range, (20) 11.0–15.2 × 4.0–5.4 μ; asci, (10) 80–88 × 8–10 μ.

The following specimens, which were all found to be in agreement morphologically with the foregoing material, were also ex-

amined and slides made for study when ascocarps were available:

D. fuscosanguinea Rehm. "mikroscopisch = Rehm. Ascom. *112*. An *Pinus pumilio,* Peischlkopf in Tyrol, c. 1800 m., July, 1878. Britzelmayr."

D. fuscosanguinea Rehm. *Pinus pumilio,* Tyrol, June, 1884. Collected and identified by Rehm, and annotated by him: spores elliptical, 12–14 × 4 μ, in 2 rows; asci, 60 × 8 μ; paraphyses filamentous; hairs c. 4 μ.

D. fuscosanguinea Rehm. Cone scales of *Pinus pumilio,* 1909, K. Arnold. Ascocarps 1–2 mm. diam. were very abundant in the specimen; spores, extreme range, (10) 11.2–15.8 × 4.4–5.6 μ.

No. 19. *D. fuscosanguinea* Rehm. Cone scales of *Pinus pumilio.* Algäu 8/1909, K. Arnold. Rehm annotated this specimen: spores ovate-elliptic, 12 × 4 μ; in 2 rows; asci, 70 × 9 μ; paraphyses, filamentous 1.5 μ. Spores showed the following extreme range, (10) 12.8–15.4 × 4.8–5.6 μ.

No. 28. *D. fuscosanguinea* Rehm. Cone scales of *Pinus Mugho,* July 3, 1910. Annotations by Rehm: ovate, elliptic spores, 12 × 4–5 μ; in one row; asci, 70 × 9 μ. The ascocarps had completely disappeared in this specimen.

No. 4. *D. fuscosanguinea* Rehm on *Pinus montana,* c. 1100, m., July 3, 1910. Rehm annotated this specimen: elliptic spores, unicellular, finally 2-celled, 12 × 4 μ; in one row; asci, 80 × 8 μ; paraphyses, filamentous, 2 μ, above 3 μ. No ascocarps in this collection.

The description which follows is that of the highland parasite originally described by Brunchorst (**1**). Lagerberg (**11**) adequately figured the fungus and discussed at length its parasitic relationship and the canker lesions associated with the fungus.

Dasyscypha Pini (Brunchorst) comb. nov., Descr. emend.

Syn: *Lachnella Pini* Brunch. Bergens Mus. Aarbog. no. 8: 8–11. 1892.

Dasyscypha fuscosanguinea Rehm, pro parte (sec Karsten: Hedwigia **34**: 8. 1895; Rabenh. Krypt.-Fl. **1**[3]: 1268. 1896).

D. monticola Diehl, in herb., Division Mycology, B. P. I., U. S. D. A.

Apothecia separate or aggregate, occurring abundantly on resinous cankers (**1**, PL. without legend; **11**, p. 146, FIG. 9) similar to those formed by the European larch canker parasite, *D. Willkommii* (Hartig) Rehm. Since the fruit bodies are often developed in large numbers and are closely crowded together, they present a beautiful sight because of their splendid color and large size (PLATE 52, FIG. 1), when the cups are fully expanded in moist weather. Apothecia distinctly stalked even at an early age, at first globose, urn-shaped, expanding as a flat disc with a bright orange hymenium, surrounded by marginal hairs covering the exciple, macroscopically decidedly pale cinnamon in color; 2–4 mm., occasionally 5 mm. diam.; with age the disc becomes a yellow-ochre, and the pale hairs may darken to a cinnamon-brown; when dry the exciple folds against itself over the center in an elongate fashion concealing the disc, and in large apothecia, the folding may occur from three places on the margin; hairs, simple, elongate, septate with short cells, moderately scabrous with minute roughenings, microscopically pale olive-buff, concolorous, longest hairs filiform, tapering, attenuate with exceedingly slender acuminate apices, 1–2 μ broad, extremities of shorter cylindrical hairs, sub-acute or obtusely rounded, 3–4 μ wide; extremities of asci cylindric, clavate, apex obtuse, extreme range, (70) 88.4–123.4 $\times$ 7.2–11.8 μ; ascospores 8 in ascus, uniseriate, hyaline, straight, unicellular, commonly becoming bicellular on germination, two or three septa, however, may be laid down, elongate elliptical, occasionally pyriform, with one apex obtuse, the other tapering to a sub-acute or acute extremity, extreme range, (272) 13.0–22.0 $\times$ 4.4–7.0 μ, commonly 15–20 $\times$ 5–6 μ; paraphyses, filamentous, outranking asci, septate, with yellowish oil drops, branched at base, of equal diameter, 1.5–2 μ wide, unswollen above (**11**, p. 147, FIG. 10).

Imperfect stage not observed in nature. Numerous mono-ascus and -spore cultures of North American and Scandinavian material on synthetic or natural pine twig media, did not produce the imperfect stage either at room temperature or in the refrigerator at lower temperatures (38°–42° F.).

Hab. The species is restricted to the genus *Pinus* occurring as a parasite in resinous cankers. It is reported on living *P. sylvestris* by Brunchorst from northern Norway—Finmark (Karasjok,

Alta), Ranen (Mo) and Valley of Målselve, 66°–69° n. lat.; by Jørstad from Norway farther south—Trondheims Bymark, 63° 27′ n. lat. and Telemark, Fyresdal, 59° 10′ n. lat.; by Lagerberg from northern Sweden—Luleå distrikt (Tärendö and Gällivare), Province Vasterbotten, Staatforst, Östra Jörnsmarken (Umeå distrikt) and in the most southern region, Gäfle-Dala distrikt (Särna in Dalarno), 61° 30′–67° n. lat.

Karsten (**9**) reported the fungus from Finland on Scotch pine but from his description it is extremely doubtful if he was concerned with the same fungus described by Brunchorst.

With regard to the distribution of the fungus, Jørstad (**7**) comments on it as follows: "Since the time of Brunchorst this pine disease has not been studied much further in Norway, and we have, consequently, no new data. I have seen no material of this fungus from southern Norway, but I feel sure it will appear at least in the more elevated pine-wood. It seems to be a pronounced parasite, even if it may live also as a saprophyte and it seems confined to species of *Pinus*" (translation by Theo. Holm). As noted above Jørstad (**8**) later found the fungus in Telemark which is the southernmost collection for the species in Scandinavia. It is interesting here to note that in Lind's revision of Rostrup's Danish Fungi (Copenhagen, 1913), the species is not listed.

In North America the fungus has never been found on Scotch pine but only on native species of five-needled pines. It has been reported by Stillinger from the West in northeastern Washington, northern Idaho, western Montana and British Columbia (Nelson) on *P. monticola*, at elevations of from 3000′–6000′. According to observational records in the herbarium of Dr. Boyce, the parasite which has not been found in the Cascade Mountains to the coast, has a frequent elevation of 3000′ or more, and is not found lower in the valleys.

The following western collections on native species of pine have been examined:

Pinus albicaulis. British Columbia:[3] *40521*, Mt. Revelstoke Nat'l Park, 4000′–5000′, 50° 45′ n. lat., coll. J. R. Hansbrough & A. A. McCready, Aug. 24, 1930 (PLATE 53, FIG. 1); *40522*, Flat

[3] Unless otherwise indicated, collection numbers denote specimens for study filed in the Division of Forest Pathology, New Haven, Conn.

Creek, 30 miles east of Revelstoke, 6000′–7500′, 51° n. lat., coll. J. R. H., Aug. 31, 1930; *40714,* D'Arcy, 3 miles west, 6000′, coll. J. R. H. & J. L. Mielke, June 1, 1931.

P. monticola. British Columbia: *53993* (Herb. P. S.), Mile 72 (Pacific Great Eastern RR. Station), Prohibition Claim Trail, Upper Birkenhead River Watershed, 4700′, coll. C. N. Partington & H. G. Lachmund, Sept. 1, 1927; *40731,* Revelstoke (10 miles north), 3500′, coll. J. R. H., Aug. 9, 1931. Washington: *2599* (Herb. C. R. Stillinger, dupl. in Herb. P. Spaulding), Mt. Spokane, 5700′, coll. H. N. Putnam, May 30, 1926; *41513,* Metalline Falls, Pend Oreille Co., 4500′, 48° 45′ n. lat., coll. H. N. P., W. A. Rockie & A. F. Lackey (dupl. *1811,* Herb. J. S. Boyce), Aug. 12, 1923. Idaho: *1208* (Herb. J. S. B.), Stony Creek Lookout, 30 miles northeast Elk River, Clearwater Co., 4500′–5000′, coll. C. R. S., Aug. 10, 1923 (dupl. in Myc. Coll., Bureau Plant Industry, Washington, D. C.); *2554* (Herb. C. R. S., in Herb. P. S.; dupl. *1208,* Herb. J. S. B.); *1452* (Herb. J. S. B.), Upper Priest Lake, Boundary Co., 3600′, coll. J. S. B., July 31, 1924; *2600* (Herb. C. R. S., dupl. in Herb. P. S.), Bear Skull, St. Joe National Forest, 6000′, coll. P. Rowe, Sept., 1927. Montana: *381* (Herb. School of Forestry, Univ. Idaho), Belton, west edge Glacier Nat'l Park, coll. C. R. S., Aug. 26, 1922.

P. Strobus. Michigan: *53083,* Keweenaw Co., Upper Peninsula, coll. J. K. Kroeber, Oct., 1930 (PLATE 53, FIG. 2); *53093,* Ojibway to Delaware Mine, Keweenaw Co., coll. L. W. Hodgkins, Oct., 1930, 47° 16′ n. lat.; *53149,* Michigame, Marquette Co., coll. L. W. H., Nov., 1930, 46° 30′ n. lat.; *53994,* 20 miles north of Calumet, Keweenaw Co., 1200′–1500′, coll. J. K. K., Sept., 1933.

Exsiccata examined:

No. *112c. Dasyscypha fuscosanguinea* Rehm on *Pinus sylvestris* in Rehm's personal herbarium at Stockholm. This specimen was collected Prov. Vasterbotten, Jörnsmarken, July 1911 and originally determined by Lagergerg. Spores, elongate elliptic, extreme range (20) 13.0–18.8 × 4.8–6.8 μ; asci, (10) 104.0–123.4 × 9.6–11.8 μ. A duplicate specimen in the herbarium, the N. Y. Bot. Garden, gave the following measurements: spores (20) 14.8–22.0 × 5.0–6.6 μ. Our observations which confirm those of Dear-

ness (**2**) indicated that these specimens showed agreement with American material of the parasite.

Swedish specimens of diseased Scotch pine (F. P. *53980*—specimen from Lagerberg's Herb.) collected by Lagerberg in Gällivare, Lapland, together with fresh material (*53835*) from the same host, collected by Prof. Hesselman in Tärendö, July 7, 1932 and sent to us for culture study, showed close morphological and cultural agreement with the North American forms collected on three species of five-needled pines.

A Norwegian specimen of the fungus collected by Jørstad (F. P. *64021,* specimen from Jørstad's Herb.) associated with *Phacidium infestans* Karst. on a young dead pine from Fyresdal situated in Telemark fylke. A few apothecia of the fungus were observed present on the needles as well as on the stem where they occurred more abundantly.

A specimen collected by Stillinger, Elk River, Idaho on *Pinus monticola* Aug. 10, 1924, determined as *Dasyscypha monticola* by W. W. Diehl in the Myc. Herb., B. P. I., U. S. D. A., is identical with American material of the parasite listed above.

CULTURE CHARACTERS

As in the *Dasyscyphae* (**4**, **5**) previously reported, ascospores of *D. Pini* germinated readily outside and inside the ascus within 24 hours when plated on 3 per cent malt agar. The spores germinated without septation or commonly became two-celled and produced one, two or more flexuous polar germ tubes. The ascospores were also observed to form two or three septa. After the fourth day, the young, slow-growing hyphae produced by the germinated spores, measured approximately 350–870 μ from tip to tip. A clumped type of colony of very sparsely branched, flexuous hyphae was produced resembling somewhat that produced by *D. Willkommii* spores, except the germ tubes were not pronouncedly "curly" (**4**, PL. 10, FIG. 5) as in the larch parasite.

A strain of the species growing on *Pinus albicaulis* (*40522*) collected August 31, 1930 was isolated April 29, 1931, after being stored in the ice box for eight months. A strain collected on *P. monticola* (*40731*), August 9, 1931, was isolated after being kept in a like manner for four and six months respectively. On steril-

ized hard oatmeal in Erlenmeyer flasks a dense, whitish, wooly aërial colony, 1 cm. diameter, was formed within a month at room temperature, whereas growth upon the malt agar was even slower. Mono-ascospore strains of collection *40522* produced at room temperature upon 3 per cent malt agar in test tubes within the same period of time, colonies 2–4 mm. in diameter, with well-developed aërial mycelium 6 mm. high, dense, whitish, having the effect of fine combed wool, which with age became tinged with light buff. It was found that while strains of the fungus from North America and Scandinavia would grow at room temperature, test tube cultures kept in the ice box (38°–42° F.) upon sterilized twigs of *Pinus Strobus* standing in hard oatmeal agar, thrived upon this medium. Upon plain oatmeal agar a veritable plug of fine, chalky-white, aërial hyphae 20 mm. high was produced within 3 months, which filled the tube above the medium. Dried out synthetic malt cultures of Scotch pine strain *53835,* which had been stored in the ice box for 18 months, grew vigorously when subcultured upon fresh synthetic malt.

A comparison of culture characters of three strains isolated from *Pinus Strobus, P. monticola* and *P. albicaulis* and the Scandinavian strain from *P. sylvestris* showed satisfactory agreement upon sterilized rice and potato dextrose agar kept at room temperature. Upon the former all the strains formed first a fine whitish, aërial growth, later tinged with buff-yellow. The white rice grains immediately below this aërial growth became a pinkish-buff. On the potato dextrose slants, all the strains grew very slowly. The white aërial growth which formed has a dense, even, circular, pompon-like colony consisting of fine white hyphae which became tinged with buff-yellow about the center of the colony within 15 days in all the tubes except those containing the Swedish strain. However, when the buff-yellow color did appear in the latter it continued to deepen to a beautiful orange-buff, whereas in the American strains the yellow color faded to a pale pinkish-buff. This difference in color reaction between American and European strains appeared to be one of degree among colonies all of which produced essentially the same type of growth.

An imperfect stage of *D. Pini* was never observed among the mono-ascus or -ascospore culture strains growing on the various

media tested. Likewise Lagerberg (**11**) commented upon the fact, that he had failed to observe this stage in the life-history of the fungus.

DISCUSSION

Although *Dasyscypha Pini* was first reported in 1892, the species was not recognnized or collected in this country until 1922. With the discovery of the disease in this country, the striking pathogenic nature of the fungus attracted pathologists, particularly because this canker disease in certain regions was confused with that caused by white pine blister rust (**6**, **15**). Mycologists instinctively sensed that the pathogen involved was very probably distinct, at least physiologically, from Rehm's *D. fuscosanguinea.* Boyce, greatly interested in the fungus, sent material to Washington for identification, which was referred to Dr. W. W. Diehl of the Division of Mycology who examined it critically. Diehl's opinion of the fungus, given in a written communication to the Division of Forest Pathology (Sept. 24, 1923), was as follows: "I have examined with much interest the *Dasyscypha* on *Pinus monticola.* . . . I am unable to find any described species with which this is identical; although the fact is the taxonomy of this genus is not definitely outlined. Your specimen comes nearest to *D. fuscosanguinea* Rehm, but differs plainly from that species in that the paraphyses are definitely branched, not thickened at the apex; the spores are frequently biseptate (as in the genus *Lachnella*); while the sizes of the asci, and even of the spores, are larger. This fungus, in connection with the cankered condition, suggests that of *Dasyscypha Willkommii* Hartig, causing larch canker, although it is definitely a different species. In external appearance this resembles *D. arida* Phill., which occurs on coniferous hosts in the western United States, but this latter species has much smaller spores and asci, and paraphyses with swollen tips."

Two years later Dearness in correspondence (March 25, 1925) with Boyce who had kept the fungus under observation since 1923, expressed the belief that Lagerberg's fungus which he (Lagerberg) had called *D. fuscosanguinea,* was closer to the American brown-excipled parasite, than to the species described and figured by Rehm. To quote Dearness: "If Lagerberg's specimen is correctly named (and I am assuming in the meantime

that it is) your No. *1452* (Herb. J. S. B.) is a vigorous example of that species. Rehm does not imply the species is parasitic. He says it inhabits withered twigs ("durren ästchen") of *Pinus pumilio* and *P. Cembra*. . . . In my next paper I should like to publish a note of your observations giving it the "brown-red" name on the strength of Lagerberg's specimen and point out discrepancies as by Rehm's description and figures" (**2**).

To those mycologists averse to the erection of new species, particularly in these days when that practice has become rampant among some workers, the allocation of the fungus described by Brunchorst and Lagerberg as a variety of the Tyrolese saprophyte, a procedure which Stillinger (**15**) followed, was sufficient to indicate the separate identity of the pine parasite. The authors, however, have preferred to use Brunchorst's name on the basis of the several good morphological as well as physiological characters which tend to set apart the pathogen as quite a distinct fungus.

The question as to whether or not the brown-excipled species belong to the genus *Dasyscypha* also came up for consideration. Nannfeldt (Nannfeldt, J. A., Studien über die Morphologie und Systematik der Nicht-Lichenisierten inoperculaten Discomyceten. Nova Acta Soc. Sci. Upsal. IV. **8**^{2}: *299*, 1932) was not disposed to place *D. fuscosanguinea* in the genus *Dasyscypha* (syn. *Trichoscyphella* Nannf.) and stated that within his opinion the systematic position of this species was not clear. When Lagerberg **12**, p. 146, FIG. 8) illustrated the anatomical structure of an apothecium of *D. Pini*, he delineated two distinct excipular layers, an outer layer of pseudoparenchymatous tissue consisting of thick walled, brownish cells ("textura oblita") from which the hairs arose, and an inner layer of loosely-woven, thin-walled, colorless hyphae ("textura intricata"). Inasmuch as the arrangement of the hyphae into layers making up the apothecia of the brown and white-haired species appears to be similar, the authors have retained the brown-excipled forms within the genus *Dasyscypha*, where they have been placed.

It does not appear likely that *D. Pini* was introduced into this country for it apparently has been here many years. The writers have had access to the field notes incorporated in the herbarium of Dr. Boyce, which contain a great deal of valuable information on

the pine canker and its parasite. To quote from Boyce's notes made August 26, 1923: "Found a number of cankers on butt (within 1'–3' of ground) in an overmature stand, trees 18–30" D.B.H. and at least 200 years old (Upper Priest Lake, Boundary County, Idaho, Elev. 3600'—parasitic on trees of all ages; most serious on saplings) showing that tree can persist in spite of attack of main stem near ground. These infections resulting in such cankers occurred when the tree was very young with needles on the stem (Resembles photographs of European larch canker; see W. E. Hiley: The fungal diseases of the common larch. Oxford. 1919)." In the case of *D. Pini* we have apparently a fungus belonging to the Arctic flora in Europe, which is also present in this country. The species is to be found in comparatively restricted areas where its peculiar life-habits definitely associated with severe climatologic conditions were possible.

In North America, *D. Pini* has been found in latitudes below those of its habitat in Scandinavia. The Upper Peninsula, Michigan collections, demonstrate that the fungus is able to grow at lower elevations and at a lesser degree of north latitude (see *D. Pini*, Hab. p. 488). In the Pacific Northwest, on the other hand, the fungus is found only at higher elevations. Stillinger (**15**), who gave the more important locations where it has been observed in the western white pine region, wrote: "As a rule, the most heavily infected areas occur at relatively high elevations, that is, 4500' to 6000', on sites where white pine is near its altitudinal limits or otherwise on a site rather unfavorable for white pine growth. However, it has been observed in young reproduction in some localities on fairly favorable white pine sites, attacking about 20 per cent of the trees. At lower elevations in other parts of the region, it occurs only as an occasional infection on the smaller limbs, killing these, but causing no other evident damage." The inference to be drawn from these findings is that latitude and elevation play very important rôles with regard to the distribution of the fungus. Moreover, its ability to endure severe climatic conditions, in districts where it readily parasitizes pine, predisposed to disease, particularly in regions representing the distributional borderline of the host species, also must be taken into account in explaining the natural range of the parasite. In the Scandi-

navian pine barrens (**11**) where the disease occurs, altitude does not play the part it does in northwestern America. Here, as in northern Michigan, it would seem to be a matter of parasitic adaptibility of the fungus in regions where the pine must needs inure itself to very strenuous growing conditions.

Dasyscypha Pini has not been collected in Maine or in other northern New England States in the natural range of eastern white pine. Dr. J. H. Faull, who has collected fungi extensively in Canada, particularly in the Gaspe Peninsula region, did not come upon it. Dr. Baxter, who made pathological observations and collected this parasite at Gällivare, Lapland in 1930 (Baxter, D. V., Observations on Forest Pathology as a part of forestry in Europe, Univ. Mich. Forest & Conserv. Bull. No. 2: 32, 1933) did not find the fungus parasitizing *Pinus contorta* in Alaska in the regions visited during two collecting trips in 1932 and 1933.

In consulting maps that give the mean temperature in degrees Fahrenheit, for the month of January in different parts of the world (A. J. Henry and others, Weather and Agriculture, U. S. D.A. Yearbook 1924, pp. 457–558), it will be noted that practically the same isotherms, 25°–30°, pass through the Pacific Northwestern, Upper Peninsula, Michigan and Scandinavian localities where *Dasyscypha Pini* has been recorded. And again if one consults the mean July temperature chart one finds a somewhat similar condition of climatic agreement indicated by isotherms 50°–65°, although the summer agreement in temperature is not so striking.

A consideration of the isolated distribution of *Dasyscypha Pini* offers interesting ground for speculation. Fernald (**3**) has pointed out that segregations of higher plants in the northern hemisphere is shown by groups, often identical species, which occur in Europe and Pacific North America but are absent from eastern Asia and eastern America. Obviously climate is largely concerned in accounting for the segregation of plant species. In the case of *D. Pini*, low temperatures are undoubtedly correlated with the ability of the fungus to parasitize pine growing with difficulty upon unfavorable sites. Average precipitation is probably another factor for consideration. These factors, together with elevation and latitude, must be taken into account in explaining the occurrence of this peculiar parasite limited to the host genus *Pinus*.

The reader raises the question, "Why has not *Dasyscypha Pini* been found among the white pine stands of New England, if not as a parasite, at least as a saprophyte?" It may be as Fernald pointed out in the case of the higher plants, that *D. Pini,* an Arctic species (granting that it is to be considered as such), may have become isolated and is so ancient as to have lost the capacity of pioneering. We know nothing of the antiquity of *D. Pini* with respect to past geologic ages. On the other hand, it may be that instead of dealing with an old species, we may be considering one comparatively newly evolved. These new forms Bisby (Bisby, G. R., The distribution of fungi as compared with that of phanerogams, in Am. Jour. Bot. **20**: 246–253. 1933) suggests, have not yet had time to spread to or become adapted in the more distant host ranges. As that writer has stated, the distribution of parasites, generally speaking, is more limited than that of saprophytes, and their spread depends primarily on the distribution of their hosts. The introduced parasites, white pine blister rust (*Cronartium ribicola* Fischer) and chestnut blight [*Endothia parasitica* (Murr.) P. J. & H. W. And.] are examples of wide distribution with relation to that of their respective hosts. In the case of *D. Pini,* however, we may be dealing with a parasite peculiarly specialized as regards the necessary environment for its existence, and for this reason limited in its present distribution.

So far as the authors know, *Dasyscypha fuscosanguinea* is restricted to the genus *Pinus* of central Europe. It has not been reported from Scandinavia, particularly in those localities where *D. Pini* has been found. The former species, according to Rehm is a high elevation species and would appear to be distinct from the shorter-spored saprophytes, *D. flavovirens* on larch from the Tirol and the widely distributed western American species, *D. arida* occurring on a number of conifers. The determination of the relationship of these saprophytes and the decision as to whether or not *D. fuscosanguinea* and *D. flavovirens* occur in North America, remain for further investigation.

Our investigations (**3**) with *Dasyscypha Willkommii* showed that the European larch parasite was to be found fruiting in immediate association with the lesions which it produced and that the saprophyte, *D. calycina* Fuckel, then came in as a secondary

organism to colonize the weakened and dying parts killed by the parasite. In a like manner, *D. Pini* is only to be found in the immediate association with the cankers which it produces. More or less limited to these cankers, the fungus continues to fruit abundantly, even after the branch or part upon which the lesions occur is dead. The fungus in America has not been observed to spread out along the branch as a saprophyte in the manner of *D. calycina*. Boyce, who made a study of the parasite in the Pacific Northwest, orally confirmed the authors in this observation. It is of interest here to note that in Sweden, Lagerberg (**11**, pp. 152–3) reported *Lachnellula chrysophthalma* (Pers.) Karst. as frequently occurring with *D. Pini* on living pine. However, he noted that *L. chrysophthalma* was to be found only as a saprophyte on the upper part of the stem which had been girdled and killed by the attack of the parasite below. The authors have confirmed this association of parasitic and saprophytic species, in northern Michigan specimens of diseased *Pinus Strobus*.

SUMMARY

Investigation of a large-spored, brown-excipled *Dasyscypha* species, associated with a destructive canker of native *Pinus Strobus, P. monticola* and *P. albicaulis* in North America and on *P. sylvestris* in northern Scandinavia, has shown the pathogen to be distinct from the innocuous saprophyte, *D. fuscosanguinea* Rehm (1881), with which it hitherto has been regarded as synonymous.

The highland parasite is referred to Brunchorst's species *Lachnella Pini* (1892) with the new combination, *Dasyscypha Pini* (Brunchorst) Hahn & Ayers. Morphological and physiological data are presented to support the separation of Brunchorst's parasite from Rehm's Alpine saprophyte of central Europe. Culture characters of *D. Pini* are given.

D. Pini appears to have a circumpolar distribution, and is to be found only at north latitudes and usually at high elevations (3000′–6000′) on cold mountain slopes or in Arctic pine barrens where climatologic conditions are exceedingly severe. A phytogeographical discussion is given.

Since Brunchorst gave the first description of the disease, very

little further study has been made of it in Norway. Lagerberg in Sweden contributed valuable pathological and mycological data with respect to the fungus. In North American the fungus was reported for the first time in 1926. Although it is now known to have been present in the United States for many years, generally distributed over the western white pine region of the Inland Empire at high elevations, the first collection of the fungus was not made until 1922. The disease has been confused with white pine blister rust in the Pacific Northwest; in the Upper Peninsula, Michigan, where it has recently been found, it presents a similar problem. A culture study has shown that North American forms isolated from the three native hosts show satisfactory agreement with isolations from Swedish material collected on Scotch pine at Tärendö in the Arctic region.

The canker caused by *D. Pini* is very similar to that caused by *D. Willkommii* (Hartig) Rehm on larch species. The fruiting cups of the former are always to be found, as in the case of the latter, in immediate association with resinous lesions in which the pathogen continues to fruit even after the branch is killed. The organism does not spread saprophytically out into the killed branch beyond. In Scandinavia, *Lachnellula chrysophthalma* (Pers.) Karst. may colonize such dead parts, in this respect resembling the saprophyte *D. calycina* Fuckel, which colonizes branches killed or weakened by the European larch canker parasite.

Grateful acknowledgment is due the Director, Dr. Gunnar Samuelsson, and Dr. Th. Arwidsson of Riksmuseets Botaniska Avdelning, Stockholm for affording the authors the opportunity of examining first-hand Rehm's personal herbarium specimens of *Dasyscypha* for this study; to Prof. Dr. Torsten Lagerberg for herbarium and fresh specimens of *Dasyscypha* (*Lachnella*) *Pini;* to Mr. Ivar Jørstad, Statsmycolog, Oslo, for information on the fungus in Norway. In the United States the authors are also indebted to Dr. J. S. Boyce, Osborn Botanical Laboratory, Yale University, for the privilege of access to his field notes and his herbarium which contains specimens of the fungus examined critically by Prof. J. Dearness, London, Ontario, Canada; to Mr. J. R. Hansbrough and other members of the Division of Forest Pathology, Bureau of Plant Industry who have collected and sub-

mitted specimens for this study; to Mr. L. W. Hodgkins and Mr. K. K. Kroeber and other members of the Division of Blister Rust Control, who likewise sent specimens for study; and to Drs. F. J. Seaver, W. W. Diehl, J. H. Faull, D. V. Baxter, H. H. Hubert and Mr. C. R. Stillinger, who have rendered valuable assistance in collecting data for the manuscript.

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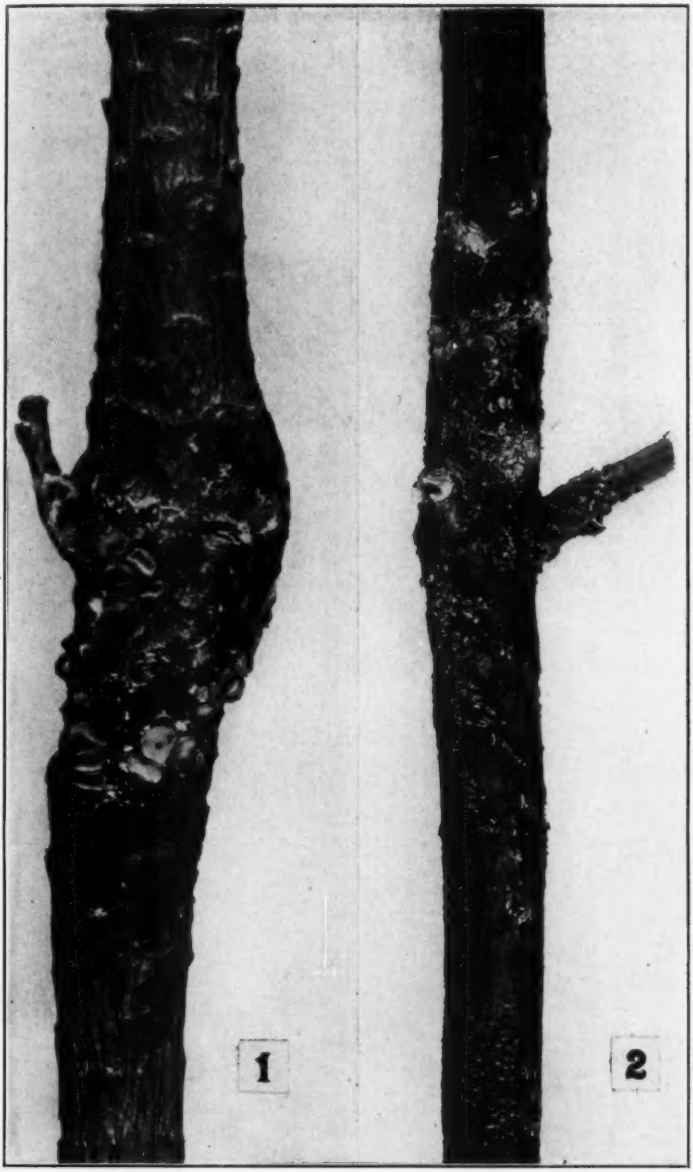
LITERATURE CITED

1. **Brunchorst, J.** *Lachnella Pini* nov. sp. Nogle norske skovsygdome. In Bergens Museums Aarbog No. **8**: 8–11. 1892.
2. **Dearness, J.** (?) *D. fuscosanguinea* Rehm. In new and noteworthy fungi—IV. Mycologia **18**: 236–255. 1926.
3. **Fernald, M. L.** Some relationships of the floras of the Northern Hemisphere. (Presented before section of taxonomy.) In Proc. Internat. Cong. Plant Sci., Ithaca, N. Y. **2**: 1487–1507. 1926.
4. **Hahn, G. G. & Ayers, T. T.** *Dasyscyphae* on conifers in North America. I. The large-spored, white-excipled species. Mycologia **26**: 73–101. 1934.
5. ——. *Dasyscyphae* on conifers in North America. II. *Dasyscypha Ellisiana*. Mycologia **26**: 167–180. 1934.
6. **Hodgkins, L. W.** A new parasitic disease attacking white pines in the upper peninsula of Michigan. In Blister Rust News **14**: 326. 1930. Mimeographed.
7. **Jørstad, I.** *Dasyscypha fuscosanguinea* (syn. *Lachnella Pini* Brunch.). In Norske skogsykdommer. Meddel. Norske Skogforsøksvesen **6**: 19–186. Oslo. 1925.
8. ——. *D. fuscosanguinea*. Furukreft, *Dasyscypha*-arter. In Skogdirektörens innberetning om norske Skogvesen, 1926–1930. P. 79. Oslo. 1931.
9. **Karsten, P. A.** *Lachnella fuscosanguinea* (Rehm) Karst. Symb. Myc. Fenn. **24**: 16. 1888.
10. ——. *Lachnella Pini* Brunckh. In Fragmenta mycologica. Hedwigia **34**: 8. 1895.
11. **Lagerberg, T.** *D. fuscosanguinea*. In Studier öfver den norrländska tallens sjukdomer, Särskildt med hänsyn till dess föryngring. In Meddel. Stat. Skogförsöksanstalt **9**: 137–148. Stockholm. 1912.
12. **Rehm, H.** *112. Dasyscypha fuscosanguinea* Rehm, nov. spec. Ber. Nat. Ver. Augsburg **26**: 30. 1881.



DASYSCYPHA PINI

13. ——. *D. fuscosanguinea.* Die Pilze Deutschlands, Oesterreichs und der Schweiz. Ascomyceten. III abtheilung. In Rabenh. Krypt.-Fl. 1[3]: 848–849. Leipzig. 1896.
14. **Saccardo, P. A.** *D. fuscosanguinea* Rehm. Syll. Fung. **8**: 459–460. 1889.
15. **Stillinger, C. R.** *Dasyscypha fuscosanguinea* Rehm on western white pine, *Pinus monticola* Dougl. Phytopath. **19**: 575–584. 1929.

EXPLANATION OF PLATES

PLATE 52. *Dasyscypha Pini* (Brunch.) Hahn & Ayers

Canker on living branch of *Pinus albicaulis* showing the brown-excipled apothecia with bright orange hymenia of *D. Pini* (*40521*). This specimen was collected Mt. Revelstoke Nat'l Park, British Columbia, elev. 4000'–5000', 50° 45' n. lat., August 24, 1930. (Approx. 4 × nat. size.)

PLATE 53. *Dasyscypha Pini*

Fig. 1, Canker on living branch of *Pinus albicaulis* (*40521*) associated with the fruiting bodies of *D. Pini.* The parasite continues to fruit in the canker after the branch has been girdled and parts above killed. (Approx. 2 × nat. size.)

Fig. 2, Canker on heavily infected *P. Strobus* (*53083*); the branch has been killed both above and below the lesion by *D. Pini.* Apothecia are shown upon the lesion fruiting in the canker. Note fruiting bodies of a secondary organism, *Coccophacidium crustaceum* (Curt.) Durand which has colonized the dead cortex below the canker. (Slightly below nat. size.)

MYCOLOGICAL NOTES FOR 1933[1]

L. O. Overholts

(with plates 54 and 55 and 1 text figure)

FUNGI IMPERFECTI

1. Ascochyta lethalis Ellis & Barth.

What appears to be the first Pennsylvania collection of this species on *Melilotus officinalis* was made near St. Marys, Elk County, Pennsylvania. The infestation was very heavy on the stems and great damage to the crop was apparent.

2. Cercospora Menispermi Ellis & Holw.

Collected on leaves of *Menispermun canâdense* in Huntingdon County, Pennsylvania, in 1930.

The original description calls attention to the preponderance of short spores in this species, 15–25 × 5–7 μ. Tehon (Mycologia **16**: 138. 1924) describes some spores as much elongated (to 140 μ) for specimens from Illinois. The spores of my collection agree better with the shorter spores of the original description, measuring 18–52 × 4–6 μ.

3. Cornularia macrospora (Berk. & Curt.) Sacc.

Collected in Center County, Pennsylvania, in 1928, on dead branches of *Robinia pseudacacia*. Pycnidia columnar, black, about 1 mm. high, 120–180 μ diameter; spores elongate, hyaline, attenuate at both ends, several-celled, 55–65 × 2.5–3 μ (plate 55, fig. 9, 13).

[1] Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, March 12, 1934, as Technical Paper No. 640. Contribution No. 97, Department of Botany, The Pennsylvania State College, State College, Penna.

For the last previous article in continuation of this series see Mycologia **25**: 418–430. 1933. I am indebted to Dr. J. Dearness, Miss Edith Cash, and Dr. W. W. Diehl for some of the determinations herein reported.

4. DIMEROSPORIUM BALSAMICOLA Peck.

This much named fungus was collected on dead leaves of *Abies balsamea* at Highlands, North Carolina, in August, 1933. It fruits abundantly on the lower leaf surfaces and sparingly on the upper surfaces. It seems to be not often collected and this probably extends its range far southward from previously reported stations. The fungus is past the sporulation stage but the pycnidia are very characteristic, especially in section.

5. DIPLOCLADIUM PENICILLIOIDES Sacc.

A species of *Diplocladium,* referred provisionally to the above species was collected in Armstrong County, Pennsylvania, in 1932. The fungous host was so much disfigured that even a generic reference was impossible in the dried condition, though the indications pointed to a species of *Pleurotus.*

Forming a soft compact mat over the gills of the substratum, white or in older portions verging toward salmon or pale orange; conidiophore hyphae extensively branched, the ultimate branches more or less verticillate, 2–4 in number, 50–70 × 4–6 μ, tapering to a point and bearing a single terminal spore; spores ovoid to ellipsoid or oblong-ellipsoid, smooth, hyaline, 2-celled, 12–18 × 6–9 μ (PLATE 55, FIG. 7).

6. HETEROSPORIUM ALLII Ellis & Mart.

Causing extensive injury to leaves of wild garlic, *Allium canadense,* in Lancaster County, Pennsylvania, in June, 1933. Not previously collected in the state, but originally described from New Jersey. Spores minutely verrucose, 24–36 × 10–12 μ, mostly 2–4-celled.

The variety *Allii-Porrii* Sacc. & Berlese was collected on *Allium* at Mt. Union, Huntingdon County, Pennsylvania, in 1929. In it the spores are 42–66 × 12–15 μ.

7. LEPTOSTROMELLA FILICINA (Berk. & Curt.) Sacc.

Seldom reported, but probably common on dead overwintered leaf stalks of various species and genera of Filicales. Material in excellent condition was collected in Center County, Pennsylvania, in 1926 and again in 1932.

Pycnidia crowded, often confluent, somewhat elongate, shiny-

black, sometimes as much as 0.5 mm. long, usually smaller, about 200 μ broad, sub-epidermal in origin and blackening the epidermal cells; conidia linear, curved or crescent-shaped, hyaline, 3–5-celled, 20–40 $\times$ 1–1.5 μ.

On dead overwintered leaf stalks of *Osmunda* and *Onoclea*.

8. LEPTOTHYRIUM PERICLYMENI (Desm.) Sacc.

The first Pennsylvania collection was made June 13, 1933, on *Lonicera canadensis*. The following notes were made:

Spots definite, circular, most conspicuous from the upper surface, 3–6 mm. diameter, the centers becoming ashen, the margin remaining red-brown; pycnidia epiphyllous, lenticular, scattered, 4–15 per spot, 120–160 $\times$ 40–60 μ, in section showing a definite black roof and a hyaline hymenial layer, apparently subcuticular in origin; conidiophores short, inconspicuous; conidia retort-shaped, *i.e.* enlarged at the basal end and tapering to an attenuated and laterally bent tip which seems to be cut off from the main body of the spore by a septum, otherwise 1-celled, hyaline, 10–13 $\times$7.5–8 μ exclusive of the tip, 16–18 $\times$ 7.5–8 μ measured along the chord to the tip. (Compare *Kabatia Periclymeni* (Desm.) Bubak.)

One might expect the attenuate spore tip to be the spore-pedicel but such is not the case (PLATE 55, FIG. 12).

9. PHYLLOSTICTA MACROSPORA Ellis & Ev.

Collected on living leaves of *Liriodendron Tulipiferae* in Armstrong County, Pennsylvania, in 1932. It inhabits spots that on other occasions harbor *P. Liriodendri* and occasionally some of Moniliales such as *Alternaria* and *Cercospora*.

Spores elongate, subfusoid to almost oblong with ends slightly pointed, 1-celled, smooth, hyaline, 16–22 $\times$ 4–6 μ. It does not seem probable that this species and *P. Liriodendri* could be synonymous.

10. RAMULARIA SAMBUCINA Sacc.

On living leaves of *Sambucus racemosa*, Sullivan County, Pennsylvania. Spots 2–3 mm. diameter, black above, paler and concave below. Conidiophores hyaline, up to 45 μ long, 2.5–3.5 μ diameter, in clusters of 15 or more; conidia cylindric, the ends slightly narrowed, 15–30 $\times$ 2.5–3.5 μ.

R. sambucina Peck is probably the same, though described as having spores 5–6 μ diameter.

11. RAMULARIA SHELDONI Trotter. (= *R. Delphinii* Dearness & House).

Collected at the U. S. Gold Corporation above Eldora, Colorado, elevation 10,000 feet, July 31, 1926, on *Delphinium* sp. Spores 15–24 $\times$ 5.5–6 μ. Originally described from Gray, Colorado.

12. SEPTORIA INCRESCENS Peck.

On leaves of *Trientalis americana*, Walden, Vermont, 1917. Spores 16–36 $\times$ 1–1.5 μ, straight, 2–4-celled. Pycnidia epiphyllous, minute.

13. SEPTORIA MIMULI Ellis & Kellerm.

On living leaves of *Mimulus ringens*. Huntingdon County, Pennsylvania, 1932. Spots sub-circular, 3–6 mm. broad, of which the major portion is the broad reddish-purple margin; pycnidia amphigenous, 60–80 μ diameter; spores linear, several-celled, 25–40 $\times$ 1.5–2 μ.

14. STEGANOSPORIUM ACERINUM Peck.

S. piriforme Hoffm. has been several times collected in Pennsylvania in recent years, but *S. acerinum* but once, and it probably is not common. It differs from the first named species in the larger spores, 45–60 $\times$ 27–31 μ, and probably in the habit of extruding them in comparatively immense tongue-like bands as much as 5 mm. broad. Potter County, Pennsylvania. On dead *Acer Saccharum*. September, 1925.

15. TOXOSPORIUM ABIETINUM Vuill.

Collected on dead leaves of *Abies balsamea* in company with *Dimerosporium balsamicola* at Highlands, North Carolina, in August, 1933. The acervuli, so far as observed in sections of this material, are merely minute clusters of spores, apparently subcuticular in origin and not discernible except by most careful study of leaf sections. Spores, however, are obtainable in crushed mounts from scrapings of the leaf surface. Peck seems to have described this as *Pestalozzia* (?) *campsosperma*, which was transferred to *Monochaetia* in the Sylloge. I have not studied the type material but the indications are that Peck obtained spores in micro-

scopic mounts and erroneously assumed them to be produced in the pycnidia of an accompanying *Dimerosporium balsamicola.*

ASCOMYCETES

16. GODRONIOPSIS QUERNEA (Schw.) Diehl & Cash.

Two collections by C. S. Moses, near Voluntown, Connecticut, extend the range of this species slightly. They were taken from living branches of *Quercus coccinea.* The excipular ridges mentioned by Diehl and Cash as a feature of the species are not prominent and would be mistaken for corrugations due to drying if specimens were not soaked up. The ascospores measure only 25–32 × 6–8 μ in my preparations, but Miss Cash agrees that the fungus is correctly referred here. The outer layer of the exciple, showing black in sections, becomes green in KOH solution and a drop of KOH containing an apothecium becomes a dirty red-brown color.

17. MYCOSPHAERELLA IMPATIENTIS (Peck & Clinton) House.

Collected in Cook Forest, Clarion County, Pennsylvania, in 1927, on *Impatiens.* Forming indefinite, inconspicuous brownish spots 4–10 mm. diameter, not sharply delimited; perithecia amphigenous, numerous, thickly gregarious, 50–80 μ diameter; asci saccate to clavate, 8-spored, 45–58 × 8–12 μ; spores elongate, smooth, hyaline, 2-celled, 10–14 × 3–4 μ

18. MYCOSPHAERELLA THALICTRI (Ellis & Ev.) Lindau.

Collected on living leaves of *Thalictrum,* in Armstrong County, Pennsylvania, in 1932. Forming small white spots 2–3 mm. long, with a very narrow darker border; perithecia epiphyllous, numerous, 60–80 μ diameter; spores biseriate, elongate, 2-celled, 9–13 × 3–3.5 μ.

19. OCELLARIA AUREA Tul.

Answering to this description is a fungus collected on dead branches of *Salix* in Armstrong County, in 1932. Apothecia 300–500 μ diameter, erumpent, opening widely, with a definite rim-like margain, it and the hymenium golden brown in color; asci 80–115 × 20–25 μ, 8-spored; spores ellipsoid, smooth, hyaline or somewhat golden, 22–27 × 11–13 μ (PLATE 55, FIG. 14, 15).

20. PSEUDOPEZIZA AUTUMNALIS (Fuckel) Sacc.

Two Pennsylvania collections have been made of this species, one in Forest County in 1921, and one in Center County in 1933, the latter on *Galium circaezans*. Apothecia 60–100 μ diameter, grouped on yellowish spots, hypophyllous; spores narrow-fusoid or cylindric with pointed ends, 7–9 $\times$ 2–2.5 μ.

BASIDIOMYCETES

USTILAGINALES

21. ENTYLOMA ARNICALE Ellis & Ev.

Collected at an elevation of 10,000 feet, above Eldora, Colorado, July 31, 1926, on *Arnica cordifolia*. The measurements of both chlamydospores and conidia under-run those given by Clinton, the former being 9–14 μ diameter and the latter 10–20 μ long. Clinton lists the species only from Idaho and Washington. *Ramularia arnicalis* Ellis & Ev. is the conidial stage of this smut and was collected at Rimini, Montana, which adds still another state to the known range.

UREDINALES

22. PUCCINIA PARCA Arth.

A rust of limited distribution on the Atlantic coast and apparently not frequently collected. A collection was made at the Gate-keeper's lodge at the foot of Mt. Mitchell, Black Mountain, North Carolina, in August, 1933. The species seems easily recognizable in the telial stage by the hyaline papillae projecting over the germ pores. Both uredinia and telia are present on this material.

23. PUCCINIA TENUIS (Schw.) Burrill.

Orton in the North American Flora records this species as occurring southward only to West Virginia. A collection made by the writer at the foot of Mt. Mitchell, North Carolina, in August, 1933, is therefore an extension of its range in that direction. Both aecia and telia are present on leaves of *Eupatorium urticaefolium* collected at the Gate-keeper's lodge at the entrance to the Mt. Mitchell road at Black Mountain. The teliospores are as much as 40 μ long, exclusive of pedicel.

24. PUCCINIASTRUM AMERICANUM (Farl.) Arth.

Reported in the North American Flora as ranging south to West Virginia. I collected it on *Rubus idaeus aculeatissimus* (= *R. strigosus*) atop Mt. Mitchell, North Carolina, in August 1933.

25. PUCCINIASTRUM HYDRANGEAE (Berk. & Curt.) Arth.

Collected on *Hydrangea radiata* at the upper falls of the White Water River, Transylvania County, North Carolina, in August 1933. This seems to be an unreported host for the species which has been known only on *H. arborescens* in the uredinial and telial stages.

HYMENOMYCETALES

26. ALEURODISCUS AMORPHUS (Pers.) Rabenh.

Collected at Cheat Mountain, West Virginia, on dead *Abies balsamea*, June 8, 1933. This extends the range of this species southward from New York to West Virginia. The spores, as I usually find them, are nearly or quite smooth.

27. ALEURODISCUS APICULATUS Burt.

A collection answering fairly well to Burt's description of this species was taken at Highlands, North Carolina, in August, 1933. The only departures from Burt's description are in the following points: in structure 400–600 μ thick instead of 600–800 μ; paraphyses (with lateral prongs) measuring 5–12 μ diameter rather than 6–7 μ; basidia up to 20 μ diameter instead of 12–15 μ; sterigmata 15–20 μ long rather than 15 μ; spores 24–28 $\times$ 12–16 μ, rather than 20–25 $\times$ 12–15 μ. While Burt's type was collected in Jamaica, yet it was at an elevation of 5,000 ft., so that the discrepancy in geographical range is not so great. I have been unable to see definite echinulations on the spores of my collection, but those species of *Aleurodiscus* that have roughened walls seem to develop such roughness relatively late and Burt remarks that two other collections seem by him from Grenada and from Porto Rico had even-walled spores and were probably immature. The shape of the spore is so highly characteristic that if my collection does not represent his species it must be quite closely related to it. The color of the hymenial surface is about that of *Corticium roseum*. Reported by Coker from North Carolina in 1927.

28. BOLETUS BETULAE Schw. and B. RUSSELLII Frost.

In 1902 Beardslee maintained (in Lloyd, Myc. Notes p. 97, 1902) that these two were phases of the same species, the differences previously noted being due to weather conditions. Murrill, however (American Boletes p. 8, 1914) maintained the two species, describing one as tomentose and with longitudinally striate spores and the other with viscid glabrous pileus and papillate spores. I collected both species in the same woodlot near Marion, North Carolina this summer. There can be no doubt but that the two species are distinct, the differences following along the lines laid down in Murrill's description. The spores in particular present a fine point of separation in dried plants.

29–32. CORTICIUM—Section Botryodea.

This section of *Corticium* seems to be a natural group of species characterized by the hypochnoid and tender structure, pale color, a more or less discontinuous hymenium that appears granular under a lens, the granules representing clusters of basidia borne in a somewhat botryoid fashion on the apexes of short lateral branches of the coarse and septate subiculum hyphae. The basidia are much broader in proportion to their length than in the usual clavate type of basidium. They differ also in often producing up to eight sterigmata on each basidium. The subiculum hyphae are very loosely arranged, of broad diameter, and with right-angle branching.

Burt recognized two species in this complex, the common *Corticium vagum* and another described under the name *Coniophora vaga*. In addition to these two I have in my herbarium American specimens of *C. subcoronatum* and specimens of a different species I am proposing as new at this time. These species are to be differentiated as follows:

Subiculum hyphae with clamp connections, 5–8 μ diameter; spores narrow-ovoid or narrow-ellipsoid and flattened on one side, to nearly cylindric and pointed at one end, 5–7 × 2–3.5 μ; basidia 5–6 μ diameter. *C. subcoronatum.*

Subiculum hyphae without clamps.

Subiculum hyphae reaching diameters of 12–14 μ or more; spores broadly ovoid or subglobose, 3.5–5 × 3–4 μ diameter; basidia 8–10 μ diameter ..... *C. botryoideum.*

Subiculum hyphae not more than 8–10 μ diameter. Spores ovoid to ellipsoid, apiculate, 6–8 × 4–5.5 μ ..... *C. fenestratum.*

Spores more elongate 7–9(—12) × 3–4.5 μ ..... *C. vagum.*

29. **Corticium botryoideum** sp. nov.

Effused as a thin hypochnoid layer, separable in small bits when wet and then tender in texture, smoky-gray to pale olive buff (Ridgway) or finally deep olive buff; in section 120–300 μ thick, composed of loosely arranged suberect hyphae 6–18 μ diameter, divided into short cells, without clamps at the septa, hyaline or nearly so or a few of those of largest diameter somewhat brownish, branching at nearly right angles, the branches ascending and terminating in short-cylindric basidia 8–10 μ diameter, with 4–8 sterigmata 3–5 μ long at maturity; spores broadly ovoid or subglobose, smooth, hyaline, 3.5–5 $\times$ 3–4 μ; cystidia and gloeocystidia none.

On the bark of prostrate limbs of deciduous trees: noted on *Acer, Alnus, Betula, Carya, Fagus,* and *Hamamelis.* Type collected at Biglerville, Adams County, Pennsylvania, on dead *Alnus rugosa,* July 26, 1932. (Overholts Herb. No. *14503.*) Other collections, all from Pennsylvania, are at hand from Jefferson, Sullivan, Huntingdon, and Armstrong Counties (PLATE 55, FIG. 10).

30. **Corticium fenestratum** nom. nov. (*Coniophora vaga* Burt; not *Corticium vagum* Berk & Curt.).

I have examined the type collection of *Coniophora vaga* and find the spores so dilutely colored that there exists no logical reason for separating the species into a different genus when its relationships are so obviously close to this section of *Corticium.* I measure the hyphae in the type collection somewhat broader then given by Burt. The broadly ovoid and rather strongly apiculate spores, and hyphae of smaller diameters (7–9 μ) make this species distinctive (PLATE 55, FIG. 5).

31. CORTICIUM SUBCORONATUM von Höhn. & Lit.

Forming a thin gray or slightly yellowish-gray discontinuous pellicle 40–80 μ thick on the surface of rotted wood, appearing velutinate under a lens, delicate and separable; in section composed of a few loosely interwoven hyphae along the substratum, these sending up branches of smaller diameter, all hyaline or nearly so, thin-walled, 5–8 μ diameter, with rather abundant clamps of rather small size for such large hyphae; spores narrow-ovoid or narrow-ellipsoid and flattened on one side, to nearly cylindric and pointed at one end, 6–7 $\times$ 2–3.5 μ; basidia 5–6 μ diameter, 4–8-spored.

On rotten wood, usually of coniferous trees. Specimens are at hand from Massachusetts and Pennsylvania.

The clamped hyphae set this species off from its relatives. For comparison, I have the species as communicated to me by Dr. Wakefield of Kew (PLATE 55, FIG. 11).

32. CORTICIUM VAGUM Berk. & Curt.

This species is easily recognized if in sporulating condition by the fusoid or *Euglena*-shaped spores. The hyphae are of small diameter (6–9 μ) and are without clamps at the frequent cross walls. It is a common species on the under side of logs of both coniferous and deciduous trees. At times it apparently revives for two or three years and then attains a thickness of 400 μ and shows a compactness of structure that is at variance with its usual thin hypochnoid condition. About 50 collections are in our herbaria (PLATE 55, FIG. 4).

33. CYPHELLA CARICINA Peck.

A good collection of this species was made in May 1933, growing on dead stems and leaves of *Carex* and *Juncus* in a swampy area near State College. The species is otherwise apparently known only from the type collection in New York. We present a photograph obtained from this material (PLATE 54, FIG. 3).

34. LENTINUS HAEMATOPUS Berk.

Pileus 4–7 cm. broad, tough, reviving well, circular to subreniform in outline, somewhat depressed to somewhat infundifuliform, the margin frequently wavy or lobed, thin, somewhat hygrophanous and pale watery-brown (close to "cream buff" or pale "chamois") when moist, ochraceous on drying, slightly radiately ribbed at certain stages of drying; context concolorous, tough and somewhat cartilaginous, thin, tasteless, but with a strong anise odor that is only slightly apparent in revived specimens; gills pallid or ochraceous, subdistant, unequal, 2–3 mm. broad, anastomosing on the stem, minutely serrated on edge, the sides covered by resinous-appearing hyphal pegs; stem central or excentric, short but distinct, 0.5–1.5 cm. long, 4–8 mm. thick, dark red, smooth or slightly rugose, glabrous or slightly furfuraceous, solid; spores cylindric, hyaline, 6–8 $\times$ 2.5–3 μ; cystidia none.

This is evidently a rare species. Peck reported two collections from New York and Kauffman found it once in Michigan. Aside from the types collected in North Carolina, these seem to be the only recorded stations. It was collected in Sullivan County, Pennsylvania, in July 1932. It is a distinct and well marked species, but might be sought in the genus *Panus*. It would seem a bit doubtful whether *P. anisatus* Henn. as distributed in the Pennsylvania State College copy of Sydow's Myc. March is the same thing (TEXT FIG. 1).

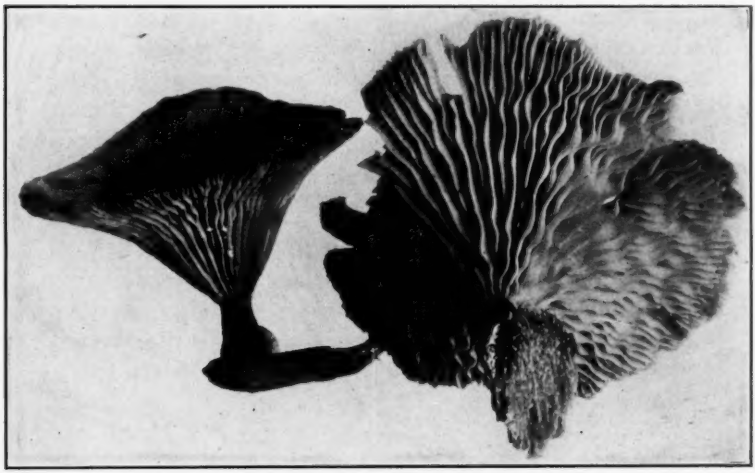


FIG. 1. Photo of *Lentinus haematopus*. ×1.

35. LEPIOTA BRUNNEA Farl. & Burt.

This is apparently the American form of *L. rhacodes*, differing in the browner pileus and somewhat larger spores. Zeller found what he considers the true *L. rhacodes* on the west coast. It has been reported only a few times in the east and probably all these eastern collections are referable to *L. brunnea* if that species is to be maintained. A fine collection was made near State College, September 7, 1933 (PLATE 54, FIG. 1, 2).

36. PISTILLARIA ABIETINA Fuckel.

Erumpent through the outer bark, first as small brown lobulate sclerotia, or the sclerotial base remaining immersed, giving rise

to one or several strongly clavate to pileate basidiocarps less than 1 mm. high, sometimes flattened and spathulate, yellowish or ochraceous, drying hard, fleshy when fresh, not at all waxy or gelatinous; basidia 4-sterigmate; spores cylindric or cylindric-ellipsoid, smooth, hyaline, 7–10 × 3–4.5 μ; cystidia none, hyphae 3–4 μ diameter, with clamps.

On dead twigs of *Pinus Strobus*. Norwich, New York. Collected by R. W. Davidson, in April, 1933.

Unquestionably referable to the genus *Pistillaria* but doubtfully referred to this species. There is at least a general agreement with the picture presented by the available descriptions. The description presented by Bourdot and Galzin seems adequate enough to cover our specimens. They record the spores as 9–11 × 4–6 μ, and the hyphae 3–5 μ diameter.

37. **Peniophora delectans** sp. nov.

Resupinate, effused as a very thin, indistinct, subpruinose, indeterminate, gray-cinereous or gray-caeruleous film; in section 20–25 μ thick, consisting of scarcely more than a basidial layer seated on the substratum; basidia hyaline, 4 μ diameter, 4-spored; spores cylindric, smooth, hyaline, 4–5 × 1.5–2 μ; cystidia abundant and conspicuous in lactic acid mounts and then erect, straight, cylindric, projecting up to 40 μ, with walls entirely thickened except for an enlargement of the lumen at the apex of the cystidium, 5–8 μ diameter, some sparingly incrusted at the tips; in KOH they are indistinct, easily overlooked, collapsed, bent, etc.; where best seen in lactic acid they extend to the substratum.

On dead wood of coniferous trees. Type collected in Cook Forest, Clarion County, Pennsylvania, June 23, 1932. (Overholts Herb. No. *16260*.)

There seems to be nothing like this described. When KOH sections are first examined the partially destroyed cystidia are so inconspicuous that one refers the species to *Corticium*. In lactic acid the cystidia are so numerous and so conspicuous and the subiculum so inconspicuous that one thinks for a moment that the cystidia are foreign to its structure. The small lumen, abruptly enlarged at the apex of the cystidium places this species in the series with *P. crassa* and *P. glebulosa*. *P. subalutacea* seems to approach nearest but that has thin-walled cystidia and the color of

the hymenial surface is very different. *P. pilosa* Burt presents some of the characters of this species but the cystidia there are thin-walled throughout and the spores are larger. *P. dissoluta* Overh. of this paper has much larger and broader cystidia that distinctly taper to a point and are thick-walled throughout. These two species and *P. glebulosa* are the only American species in which the cystidia dissolve and disappear in KOH (PLATE 55, FIG. 8).

38. **Peniophora dissoluta** sp. nov.

Widely effused as a thin sub-pruinose, discontinuous, pale olive gray to pale vinaceous fawn (Ridgway) film, shortly pilose under a lens, the margin indeterminate; in section 25–40 μ thick, composed almost entirely of the basidial layer, but with a very thin subiculum that becomes more visible beneath the slight elevations in the hymenial surface, and then seen to be of colorless and unincrusted hyphae; spores cylindric, hyaline, 4–5 $\times$ 2 μ (not seen attached to basidia); cystidia quickly dissolved in KOH solution leaving nothing but the very narrow lumen contents, but undissolved in lactic acid and then seen to be very numerous, elongated, tapering to a rather sharp point, not at all or only slightly incrusted, originating at the substratum, thick-walled with a very narrow lumen that is not enlarged at the apex of the cystidium, 120–160 $\times$ 8–11 μ, projecting for most of their length and often somewhat curved; gloeocystidia none.

On dead decorticated wood of deciduous trees. Type collected at Musser Gap, Center County, Pennsylvania, April 25, 1933. (Overholts Herbarium No. *16264*.)

In Burt's classification this species would seem to belong in the *P. crassa—P. glebulosa* group, although the cystidia are not cylindric. *P. pilosa* Burt has thin-walled cystidia of much smaller size, usually terminated by moniliform bodies, not dissolved in KOH, and the spores are somewhat different. *P. Albugo* Burt, in another group, has smaller cystidia that are not dissolved in KOH and the spores are larger. *P. delectans* Overh. of this paper has cylindric cystidia that are incrusted at the apex and the lumen is there enlarged as in the *P. crassa* group. When sections are mounted in KOH, and even before one can examine them under the microscope the walls are dissolved, leaving only the bent and

1, 2, LEPIOTA BRUNNEA. 3, CYPHELLA CARICINA

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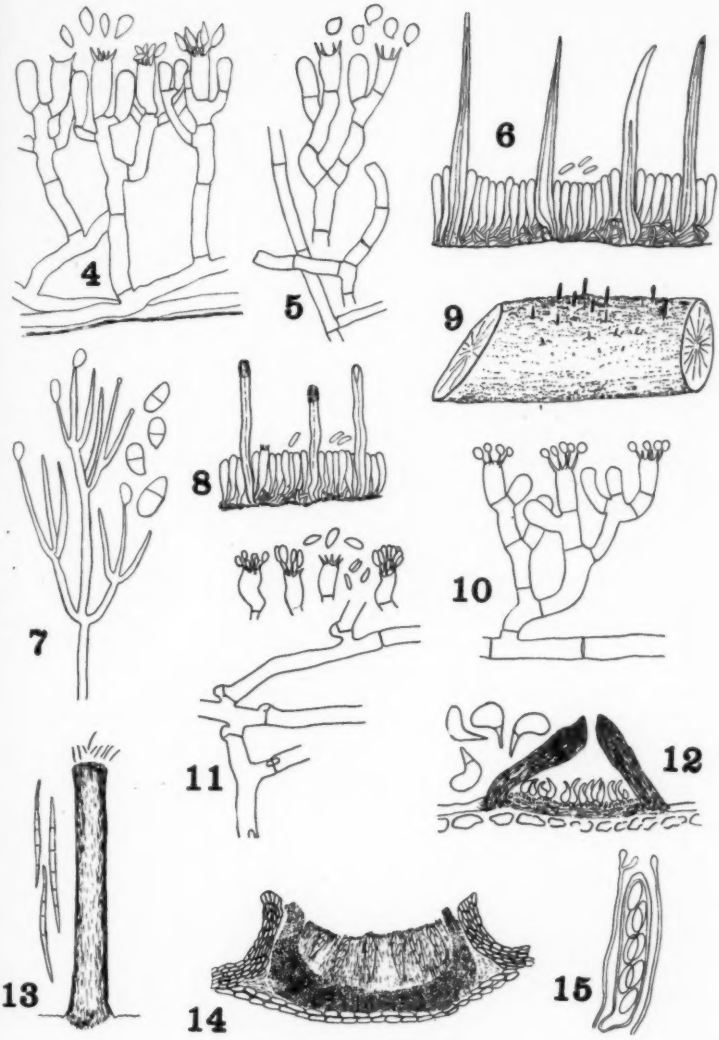

MISCELLANEOUS FUNGI

twisted lumen-contents projecting above the basidia as narrow hair-like structures (PLATE 55, FIG. 6).

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EXPLANATION OF PLATES

PLATE 54

Fig. 1, 2, *Lepiota brunnea* Farlow & Burt. Somewhat reduced; 3, *Cyphella caricina* Peck. × 2.

PLATE 55

Fig. 4, Structure of *Corticium vagum* showing the few substratal hyphae producing occasional erect branches that develop a more compact basidial layer, × 360; 5, *Corticium fenestratum.* Hyphae, basidia, and spores, × 360; 6, *Peniophora dissoluta.* Vertical section through the very thin sporophore, showing the basidial layer, spores, and cystidia, the latter thick-walled and with a lumen of uniform diameter (from lactic acid mount), × 360; 7, Conidiophore and spores of *Diplocladium penicillioides,* × 375; 8, *Peniophora delectans.* Vertical section through the very thin sporophore, showing the basidial layer, spores and cystidia, the latter incrusted at the tips in two cases, the third with incrustation dissolved off and showing the abruptly enlarged lumen at the apex, × 360; 9, *Cornularia macrospora.* Habit sketch of the columnar pycnidia on branch of *Robinia,* × 3; 10, *Corticium botryoideum.* Hyphae, basidia, and spores, × 360; 11, *Corticium subcoronatum.* Hyphae, basidia, and spores, × 360; 12, *Leptothyrium Periclymeni.* Section through pycnidium, and spores, × 175; 13, *Cornularia macrospora.* Single columnar pycnidium and the septate spores, × 250; 14, *Ocellaria aurea.* Section through apothicium, × 100; 15, *Ocellaria aurea.* Ascus, spores, and paraphyses, × 200.

LIFE HISTORY OF A CERCOSPORA LEAF SPOT FUNGUS OF COWPEA

DENNIS H. LATHAM [1]

(WITH PLATE 56 AND 2 TEXT FIGURES)

Among the diseases of cowpea, *Vigna sinensis* (L.) Endl. in North Carolina is one which appears as lesions on the leaves and stems. This disease has been known for at least forty years, as it was reported from Mississippi as early as 1891. It has now been under observation by the writer since September, 1931, and it is the purpose of this paper to report certain results obtained from a study of the life history of the causal organism.

SUSCEPTS

Although the writer has observed this disease on *Vigna sinensis* only, the causal fungus, *Cercospora cruenta*, Sacc., is apparently not limited to this suscept. A considerable number of other plants have been listed by various collectors as suscepts. Specimens on the following plants have been deposited in the Herbarium of Mycological and Pathological Collections, Bureau of Plant Industry. *Colopogonium sp., Dolichos sp., D. sesquipedalis, D. sinensis, Phaseolus sp., P. aureus, P. vulgaris, Vigna Catjang, V. sinensis,* and *V. unguiculata.*

THE DISEASE

Range:

This leafspot disease is apparently widely distributed. According to the files of the Plant Disease Survey, *Cercospora cruenta* has been reported as occurring on *Vigna sinensis* from Alabama, Ar-

[1] From a thesis submitted in partial fulfillment of the degree of Master of Arts in the Graduate School of Duke University.

The writer wishes to express his appreciation to Dr. F. A. Wolf, under whose guidance the work was done and manuscript prepared; also to Dr. S. G. Lehman, of the North Carolina State College, for suggestions in preparing this manuscript.

kansas, Delaware, Florida, Georgia, Illinois, Indiana, Kansas, Maryland, Mississippi, New Jersey, North Carolina, South Carolina, Texas and Virginia. It has been reported also from Sumatra in the Dutch East Indies.

Symptoms:

The disease is most frequently seen on the leaves, but may occur also on the stems. On leaves, reddish brown spots appear as the most prominent early symptom. Later the tissue in these spots becomes necrotic. In size, the diseased areas may vary from a few millimeters to a centimeter or more in diameter. The outline may be rather regular to very irregular. Text figure 1 shows a leaf and an extra leaflet from naturally infected plants in the field. When infection is more severe the spots sometimes coalesce, forming large necrotic areas as is shown in figure 1. 'In figure 2, leaflets *a, b,* and *d* were covered with a grayish-black coating of conidiophores and conidia. Leaflet *c* shows definite lesions at the places where inoculations were made with a watery suspension of conidia taken from an old diseased leaf.

When conidia are being formed, the lesions are usually irregular in outline and reddish brown in color, when viewed from the upper surface of the leaflet. On the lower surface of the leaflet, the lesions are irregular in outline and reddish brown in color at first, but when the pathogen is fruiting abundantly they are dark gray to black, due to the presence of numerous conidiophores and conidia.

THE CAUSAL ORGANISM

Pathogenesis:

It is not known whether the pathogen gains entrance to the suscept by direct penetration of the epidermal walls or through the stomata. Once the germ tube has entered, the fungus develops rather slowly, and the mycelium is, at first, intercellular. The pathogen absorbs at least a part of its nutriment from the surrounding cells by means of haustoria (PLATE 56, FIG. 1). The early stage of the development of the pathogen produces a plesionecrotic condition and when the attacked cells have reached the holonecrotic condition, the mycelium may then become intracellular. Then both inter- and intracellular mycelium may be found

in the same lesion. Plate 56, figure 2, shows intercellular mycelium completely surrounding several cells.

Morphology:

After the pathogen has become established in the suscept, development preparatory to asexual reproduction begins. A single hypha branches and rebranches to form a loosely interwoven, intercellular stroma (PLATE 56, FIG. 3 and 4). The stromata usually develop in the substomatal cavities but sometimes at other places. From the stromata arise erect, dilutely olive, loosely fasciculate branches, the conidiophores. They are usually simple but may be forked or somewhat subdenticulate (PLATE 56, FIG. 5). The number and length of the conidiophores varies, apparently, with conditions under which they grow. If there is an abundance of moisture, the fungus seems to grow more luxuriantly and to produce more and longer conidiophores and conidia than when it is growing under comparatively dry conditions.

The conidia which this fungus produces (PLATE 56, FIG. 11) are acicular-obclavate, slightly curved, acute above, and hyaline becoming olive. Measurements of over one hundred conidia taken from lesions on living leaves show that they range from 35–154 $\times$ 3.5–4.5 μ. The average size of the conidia is 62.5 $\times$ 3.7 μ, with 5 septa, which very closely approximates the size given by Saccardo (7) for *Cercospora cruenta* Sacc.

Spermogonial stage:

During the latter part of September small, punctiform, fruit bodies (PLATE 56, FIG. 8) resembling pycnidia were present in old lesions and were observed to be discharging large numbers of pycnospore-like bodies having the appearance of spermatia. Since no spore forms other than conidia had previously been reported for *Cercospora cruenta,* some of the diseased leaf and stem material was collected and stored in a wire cage out of doors, in order to trace the development of the pathogen during the winter. Spermogonia were present at all times and were actively discharging spermatia, when observed at intervals, between the latter part of September, 1931, and June 1, 1932.

The spermogonia develop within subepidermal stromata. Apparently these stromata may or may not have previously given rise to conidiophores, yet spermogonia have been observed bearing

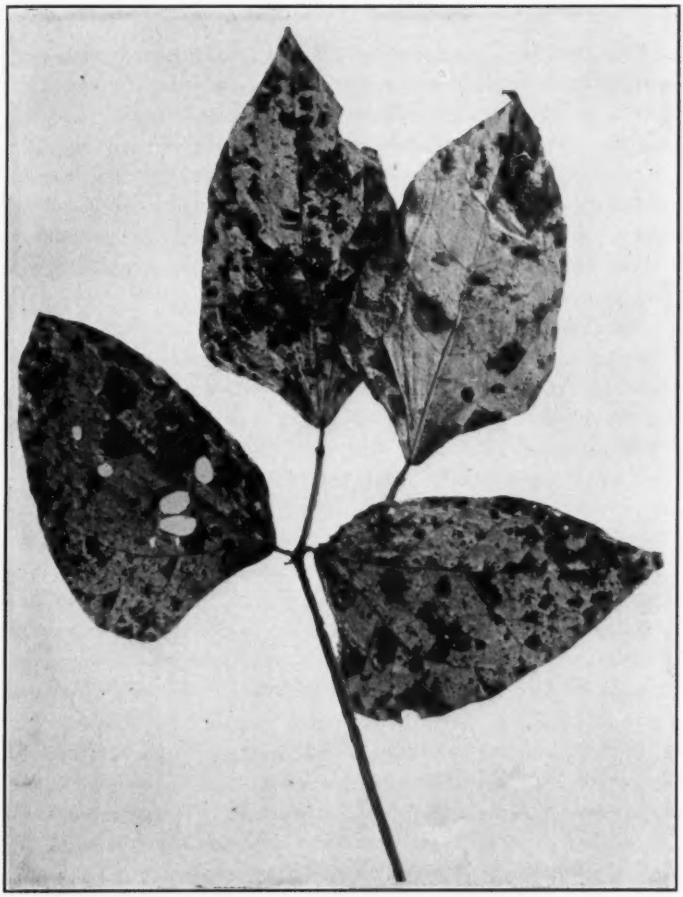


FIG. 1. Leaf of cowpea infected with the fungus.

conidiophore bases on their exposed surfaces (PLATE 56, FIG. 6). The mature spermogonia measure 31–77 × 24–70 μ. The mature spermatia are hyaline and rod-shaped and measure 2–2.5 × .8 μ.

All attempts to germinate them in tap water have failed. This is in accord with the findings of other investigators who have worked with similar stages of other species of *Cercospora* (**4**, **5**, and **6**).

Perithecial stage:

Examinations of the stored material were made at intervals of two weeks throughout the winter and spring. Early in January structures that were interpreted to be perithecial initials were observed. The perithecia develop from old subepidermal stromata and become differentiated into an inner pseudoparenchymatous medullary portion, surrounded by an outer layer or rind of a thickness of one to two brownish, thick-walled cells. The medullary tissues disappear as the asci develop. Mature perithecia are slightly beaked and measure 52–70 × 63–87 μ.

The cytological development of this species has not been fully investigated, but sectioned materials show that it is similar to that described by Higgins (**4**) for *Mycosphaerella Bolleana* Hig. and for *M. cerasella* Aderh. by Jenkins (**6**). All the asci in the same perithecium do not mature at one and the same time. One may find very young asci, in which the spores have not yet been delimited, and others which are fully matured and contain eight mature ascospores. The oldest asci are formed at the center of the perithecium and the youngest toward the lateral walls. Mature ascospores were not found before April 1. The asci are cylindric-clavate, 35–52 × 7–10 μ, bitunicate, the inner membrane excentrically papilliate, and eight-spored, the ascospores are usually arranged in two rows until the elongation of the inner ascus membrane takes place.

While examining perithecia in hanging drops of water, under the microscope, ascospores were seen to be forcibly discharged. In a number of cases the perithecia were so oriented that the tips of the asci could easily be seen when they had elongated and extended through the ostiole. Some of the asci extended as far as thirty microns beyond the orifice of the perithecium. In order to determine how the asci elongate, a perithecium was dissected from the leaf material and mounted in a drop of water on a glass slide with a cover glass over it. The perithecium was then observed under the low power and was crushed by pressing gently against

the cover glass with a dissecting needle. When a perithecium, containing mature asci, is carefully crushed, the asci are extruded in a group. With such a group of asci, one can observe the entire process of spore discharge which takes place about as follows. When the ascus is ready to discharge its spores the outer membrane breaks along one side near the apex (PLATE 56, FIG. 9 AND 10), and the inner membrane quickly elongates to 2 or 3 times its original length. By the time the inner membrane of the ascus is fully extended there is usually a single spore at its apex. Within a few seconds the remaining seven ascospores move toward the apex of the ascus. The spore at the apex is forced against the wall and soon penetrates at a point slightly to one side of the apex. The ascospores may be ejected through the water as far as fifty microns. Discharge of the first spore may be followed, singly and in rapid succession by the remaining seven spores, but there may be an interval of several minutes between discharges, or apparently sometimes the membrane is broken in another place and the seven spores are discharged in a group. The method first described is the one usually observed. As the spores are being discharged through the apical pore they are usually halted momentarily as the slight constriction at the septum comes into the opening in the ascus membrane (PLATE 56, FIG. 10). When an ascus has discharged its spores and is retracted it collapses or it may collapse without being retracted. Another ascus is then extended through the ostiole to discharge its spores in the same way. Usually more than one ascus at a time protrudes through the ostiole to discharge its spores; as one is retracted or collapsed it may be replaced by another until all the mature asci have ejected their spores.

The nature of the force that brings about the elongation of the asci and the discharge of the ascospores is not clearly understood. It was suggested by Walker and Andersen (3) that there is a considerable quantity of glycogen stored in the asci. Usually the glycogen is confined to the region below the spores, and exerts little or no osmotic pressure, but is capable of becoming rapidly transformed into sugars of high osmotic value. Such a transformation and the consequent absorption of water may be responsible for the bursting of the asci and the violent ejection of their spores. This seems to be a reasonable explanation for the violent discharge

of ascospores, especially where the spores come out in a jet. When the spores are discharged singly, as in the fungus under consideration, one must also look for an explanation of the mechanism by which the pressure within the ascus is increased, after a spore is

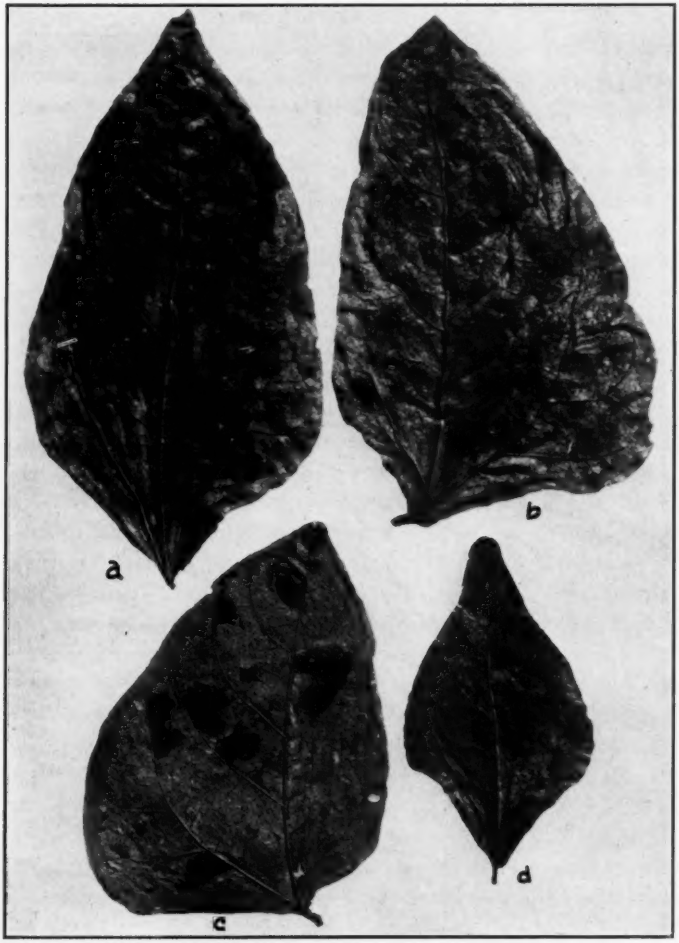


FIG. 2. Infected leaflets covered with a coating of conidiophores and conidia.

discharged, to such an extent that a second one is forced out, and so on until the eight spores have been discharged seriatim. The inner membrane, which may elongate to 2 or 3 times the length of the outer membrane, must be quite elastic. It is thought that the pore in the ascus tip closes quickly and tightly when a spore passes through it, due to the elasticity of the membrane, and that the osmotic pressure is again increased sufficiently to cause the discharge of another spore due to the transformation of more glycogen into sugar and to the absorption of more water.

When the ascospores are mature they are hyaline, unequally two-celled, and measure 11.0–19.2 × 3.5 μ, as determined by measurement of twenty-six ascospores. Only two were found to be less than 14.0 μ and only one more than 17.5 μ, in length. These three were 11.0, 13.0, and 19.2 μ respectively. Twenty-three of the twenty-six ranged from 14.0–17.5 μ, with over half of the total number measuring 17.5 μ. The ascospores germinate (PLATE 56, FIG. 7), by germ tubes growing directly out of the ends of the spore.

Isolation and culture:

The fungus has been cultured on bean agar, a decoction of cowpea leaves with agar, pieces of cowpea stem in test tubes with enough agar in the bottom of the tube to hold the stem in place and to furnish moisture, plain agar, plain agar with 2 per cent of dextrose, and potato agar with 2 per cent of dextrose. The fungus grew well on all media except plain agar. Potato dextrose agar seemed to be the most favorable one and was selected as the medium on which to study the fungus in culture.

A pure culture of this fungus, originating from a single conidium, if allowed to grow undisturbed for about four weeks on potato dextrose agar attains a diameter of approximately two centimeters. When growth first becomes visible to the unaided eye, the cultures are whitish, but as growth proceeds the mycelium becomes light gray, and by the end of two weeks has become dark gray to black. The center of the colony is usually slightly raised.

Species of *Cercospora* are regarded as being unable to produce conidia in artificial culture, except in the case of a few species. The writer used a modification of the method outlined by Ezekiel

(2) to obtain single spore cultures of the cowpea leaf spot fungus. These cultures were allowed to grow for about a week before being examined for the presence of conidia. Some of these cultures were subsequently examined every three or four days until they were about six weeks old, but no conidia were ever found. It was then decided to examine very young cultures in the search for conidia.[2] Accordingly, the writer made other single spore isolations, and found that conidia began to appear after about thirty-six hours and were rather numerous after about forty-eight to seventy-two hours. Conidia were scarcely ever found in cultures over five days old, and never occurred in cultures over ten days old. These conidia (PLATE 56, FIG. 12) appeared normal in every way and germinated in tap water. Likewise pure cultures originating from ascospores have given rise to typical *Cercospora* conidia, several of which are shown in plate 56, figure 13.

Pathogenicity:

Inoculation experiments have been conducted in the greenhouse to determine the pathogenicity of the fungus. On March 9, 1932 the tip leaflet on each of five leaves on a mature plant were inoculated with a watery suspension of conidia, obtained from a diseased plant growing in the greenhouse. These inoculations were made by placing, with a small pipette, drops of the inoculum on the leaflets. On April 11, a very definite *Cercospora* lesion was noted on one of the leaflets and a spot that appeared to be a *Cercospora* lesion was developing on another leaflet. On May 15, all the leaflets that had been inoculated showed definite *Cercospora* lesions, while the uninoculated leaflets remained healthy. On May 30, the tip leaflets on each of six leaves were inoculated with ascospores taken from old stems that had been out doors all winter. This inoculum was prepared by isolating single perithecia, washing them in changes of distilled water to remove bacteria or any conidia that might be present, mounting them in small drops of water on cover glasses, and examining with the microscope. The examinations were made by placing the cover glass over the depression in a hollow-ground slide. Each drop of inoculum thus prepared con-

[2] Suggested by Mr. Clatus M. Nagel, Department of Botany, Iowa State College, Ames, Iowa.

tained twenty-five or more mature ascospores. Infection was not evident when the plants were examined on June 12, but by June 20, lesions had formed and were covered with a felt of conidia. This fact together with the data previously given seem to constitute conclusive evidence that the ascomycetous stage and the conidial stage are genetically connected.

Briefly stated, the evidence of the genetic relationship of the conidial, the spermogonial, and the perithecial stages of the fungus here considered is as follows:

1. By observing leaf and stem material periodically from September until the following June it was found that conidia, spermogonia, and perithecia developed successively in the same lesions.

2. Spermogonial and perithecial initials have been observed to arise, from or in the old conidial stromata (PLATE 56, FIG. 6).

3. Typical *Cercospora* conidia have been found in artificial cultures (PLATE 56, FIG. 12 AND 13) isolated from conidia or from ascospores of this fungus.

4. The symptoms produced when leaves were inoculated with conidia were identical with those produced on other leaves inoculated with ascospores.

The characteristics of this fungus, in its ascigerous stage, are like those of the genus *Mycosphaerella*. Since no *Mycosphaerella* stage of *Cercospora cruenta* Sacc. has previously been described, the writer herein proposes the following new combination with brief description.

Mycosphaerella cruenta (Sacc.) comb. nov.

Cercospora cruenta Sacc. Michelia **2**: 149, 1880.

Perithecial stage:

Perithecia scattered or slightly aggregate, amphigenous but mostly hypophyllus, innate but erumpent at maturity, globose, black, ostiole only slightly papillate, 52–70 × 63–87 μ; asci fasciculate, cylindric-clavate, aparaphysate, bitunicate, excentrically papillate at apex of inner membrane, eight spored, 35–52 × 7–11 μ; the ascospores unequally bicellular, the upper cell somewhat larger, very slightly curved, hyaline, 11–19.2 × 3.5 μ (mostly 14.0–17.5 × 3.5 μ), on decaying leaves and stems of *Vigna sp.*

Spermogonial stage:

Spermogonia scattered in and near lesions produced by the conidial stage, globular-flask shaped, black, sub-epidermal at first, later erumpent, ostiolate, 31–77 × 24–70 μ; spermatia rod-shaped, hyaline 2–2.5 × .8 μ.

Conidial stage: Cercospora cruenta Sacc.

Lesions circular to very irregular, often coalescent, varying in size up to 2 cm. or more, reddish brown; conidiophores amphigenous, arising usually from substomatal stromata, loosely fasciculate, usually simple but may be forked, somewhat subdenticulate and dilutely olive; conidia acicular-obclavate, slightly curved, may be 35–154 × 3.5–4.5 μ, and 1–8 septate, hyaline becoming olivaceous.

On living leaves and stems of *Vigna sps. Dolichos sps.* and *Phaseolus sps.*

Peritheciis sparsis vel subgregariis, hypophylis rarissime amphigenis, innatis, saepe maturitate erumpentibus, globosis, atris, ostiolo minuto perforantis, 52–70 × 63–87 μ: ascis fasciculatis, oblongo-clavatis, non-paraphysatis, bi-tunicatis, ascostomate aliquantillo a latere, octosporis, 35–52 × 7–11 μ; sporidiis distichis, bicellularibus, cellula superiore leniter latiore vix curvatis, hyalinis, 11–19 × 3.5 μ, plerumque 14–17.5 × 3.5 μ.

Hab. in emortuis foliis acque ramis *Vignae sp.*

Spermogonis autumno efformantis, globosis, nigris, immersis, deinde emergentibus, punctiformibus, 31–77 × 24–70 μ; spermatis cylindricis, hyalinis, 2–2.5 × 0.8 μ, Hab. in folliis dejectis.

Status conidicus: Maculis orbicularibus v. irregularibus, amphigenis, confluentibus, magnis, rubro-ferrugineis; hyphis fertilibus amphigenis, a stromate orientibus, laxe fasciculatis, simplicibus rare ramosis, sursum subidenticulatis, dilute olivaceis; conidiis aciculari-obclavatis, rectis v. leniter curvulis, 1–8-septatis, dilute olivaceis, 35–154 × 3.5–4.5 μ.

Hab. in folliis acque ramis vivis *Vignae sp., Phascoli sp.* acque *Dolichi sp.*

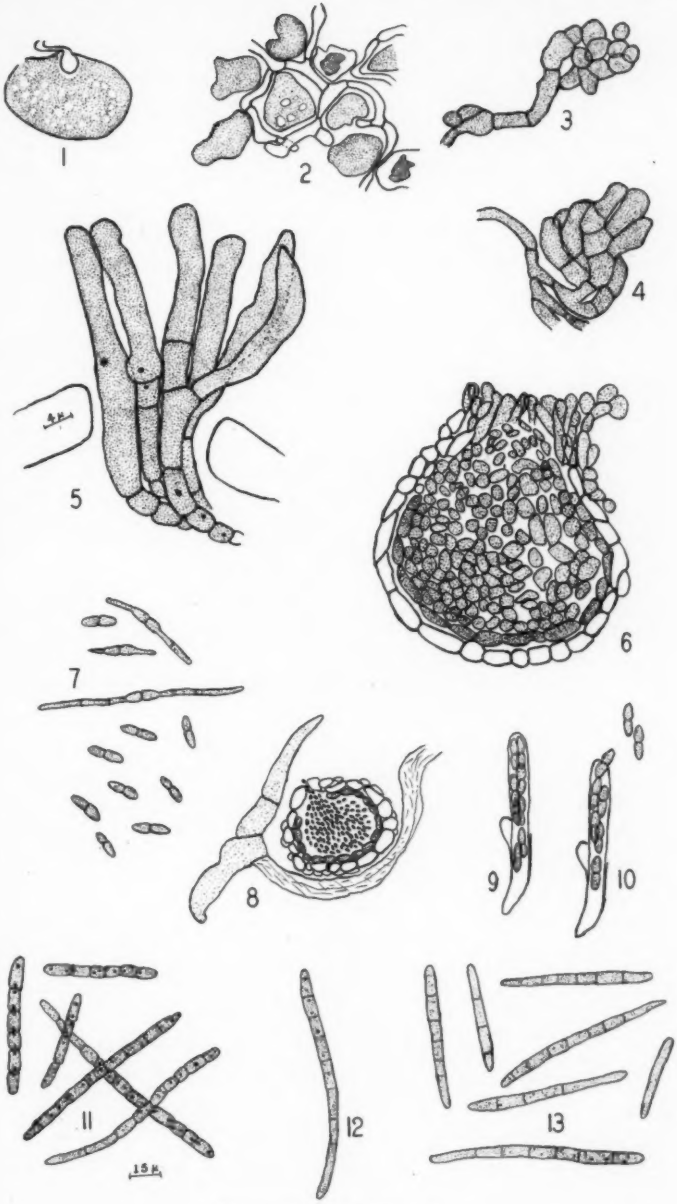
SUMMARY

This report deals with a fungus, here designated by the new combination *Mycosphaerella cruenta,* that causes a leaf and stem spot disease of cowpeas.

Lesions on the leaves are usually irregular and reddish brown. Those on the stems have not been observed to bear conidia.

The fungus has three spore forms in its life cycle. Two of these are herein described for the first time.

This disease has previously been attributed to the conidial stage,



MYCOSPHAERELLA CRUENTA

Cercospora cruenta Sacc., but evidence of the genetic connection between this conidial stage and its newly found spermogonial and perithecial stages is given.

The pathogen has been isolated in pure culture from conidia and from ascospores, both of which gave rise to typical *Cercospora* conidia.

The pathogenicity of this fungus has been established by inoculation experiments with conidia and with ascospores.

LITERATURE CITED

1. **Anderson, P. J., & others.** Check list of the diseases of economic plants in the United States. U. S. D. A. Dept. Bull. 1336, 1926.
2. **Ezekiel, W. N.** Modified procedure with the Keitt single-spore method. Phytopath. **20**: 583–586. 1930.
3. **Walker, L. B., & Andersen, E. N.** Relation of glycogen to spore ejection. Mycologia **17**: 154–159. 1925.
4. **Higgins, B. B.** Morphology and life history of some Ascomycetes with special reference to the presence and function of spermatia. I. *Mycosphaerella Bolleana* n. sp. Am. Jour. Bot. **7**: 435–444. 1920.
5. ——. Idem. II. *Mycosphaerella personata* n. sp. Am. Jour. Bot. **16**: 287–296. 1927.
6. **Jenkins, W. A.** The cherry leaf-spot fungus, *Mycosphaerella cerasella* Aderh., its morphology and life history. Phytopath. **20**: 329–337. 1930.
7. **Saccardo, P. A.** Fungorum extra-Europaeorum Michelia. **2**: 136–149. 1880.

EXPLANATION OF PLATE 56

Fig. 1, a single host cell penetrated by a haustorium; 2, a group of host cells surrounded by mycelium; 3 and 4, a single hypha showing how it branches and rebranches to form a stroma; 5, a fascicle of conidiophores protruding through a stoma; 6, an immature spermogonium; 7, a group of ascospores; 8, a mature spermagonium producing spermatia; 9 and 10, asci showing elongation of inner membrane and discharge of ascospores; 11, conidia from lesions on cowpea leaves; 12, a single conidium produced in artificial culture originating from a single conidium; 13, a group of conidia from a culture originating from a single ascospore.

A SAPROPHYTIC SPECIES OF CATENARIA ISOLATED FROM ROOTS OF PANICUM VARIEGATUM

JOHN S. KARLING

(WITH PLATES 57 AND 58 AND 3 TEXT FIGURES)

In the course of attempts to determine the degree of parasitism and host range of *Cladochytrium replicatum* Karling during the summer of 1933 a large chytrid was encountered in dead roots of *Panicum variegatum* which had been placed in a battery jar containing young growing plants of *Eriocaulon septangulare*. The large size and extensive ramifications of many thalli among the host cells were strikingly different from those of any other chytrid the author had so far observed and led to the belief at first that this species represented perhaps a new group of chytrids, but a more intensive study of its structure and development in a wide range of host plants has shown that it is undoubtedly a species of *Catenaria* which is very ubiquitous in distribution and structure. Species of this genus may infect a wide variety of plant and animal tissues, and, as has recently been shown by J. B. Butler and Humphries (1932), can readily be grown on artificial media. Under such conditions the thalli become extensively developed and are markedly variable in size and structure. The species which occurred in sterile roots of *Panicum variegatum* is strikingly similar to *C. Anguillulae* when grown on artificial media, and for this reason it is premature to give a specific name before a more extensive study has been completed.

HOST RANGE

The fact that *Catenaria* sp. occurred so abundantly as a saprophyte in roots of *Panicum variegatum* suggested that it might be cultured in other sterilized tissues as well, and a study was thus begun of its host range. It was soon found to be very ubiquitous in this respect and could be grown on a wide variety of plant and animal tissues, including nematodes, insects, algae, liverworts,

mosses, water ferns and flowering plants. In the following table are given the tissues which have been tested to date and the

TABLE 1

SHOWING THE VARIOUS STERILIZED PLANT AND ANIMAL TISSUES INFECTED WITH *Catenaria sp.*

Plants

Family	Species	Parts infected
Vaucheriaceae	*Vaucheria* sp.	
Oedogoniaceae	*Oedogonium* sp.	
Zygnemaceae	*Spirogyra crassa*	
Characeae	*Nitella flexilis*	Internodes, nodes and rhizoids
	N. glomerulifera	"
	Chara coronata	"
	C. zeylanica	"
	C. delicatula	"
	C. contraria	"
Ricciaceae	*Riccia fluitans*	Thallus, ventral scales
Marchantiaceae	*Marchantia polymorpha*	"
Anthocerotaceae	*Antoceros* sp.	Thallus
Sphagnaceae	*Sphagnum* sp.	Rhizoids
Filicales	*Osmunda regalis*	Gametophytes
Isoetaceae	*Isoetes lacustris*	Roots and fleshy parts of sporophylls
Selaginellaceae	*Selaginella erythropus*	Roots
	S. elegans	"
	S. emiliana	"
Marsileaceae	*Marsilea quadrifolia*	"
	Pilularia sp.	"
Ceratophyllaceae	*Ceratophyllum* sp.	Fleshy leaves
Ranunculaceae	*Ranunculus* sp.	Roots
Commelinaceae	*Tradescantia virginica*	Fleshy soft stems and roots
Liliaceae	*Hemerocallis fulva*	Roots
	Allium Cepa	"
	Lilium canadense	"
Iridaceae	*Iris* sp.	"
Gramineae	*Hordeum* sp.	Roots, scutellum, and bases of young leaves
	Zea Mays	"
	Avena sativa	"
	Triticum vulgare	"
	Lolium sp.	"
	Panicum variegatum	"
Sparganaceae	*Sparganium* sp.	Roots
	Alisma plantago	"
	Sagittaria lorata	"
	S. longirostra	"

Animals

Rotifers	Various species	Eggs
Infusoria	Various species	Cysts
Insects	*Drosophila melanogaster*	Eggs

results obtained. In all tests the tissues were autoclaved in a beaker for approximately twenty minutes to insure sterility and then placed in beakers containing infected material. It is to be

noted in this table that rhizoids, roots, underground parts, and the more meristematic tissues are the principal tissues infected.

The most favorable tissue so far found for study of the structure and development of the thallus are dead onion roots. Within 12 hours the epidermal and sub-epidermal cells become heavily infected, and thalli in all stages of development may be found in great abundance. In such roots which have been boiled for approximately 10 minutes the central region and the greater part of the cortex separate readily in a day or two from the epidermal and subepidermal cells, and may be easily squeezed out at the cell end, leaving the latter in the form of an empty cylinder. Then by slitting the epidermis open and spreading it out flat on a slide, the chytrid may be seen and studied with remarkable ease and clearness. As many as 600 thalli in different stages of development have been counted in a 7 mm. long bit of such tissue.

Catenaria Anguillulae also has been reported by Sorokin (1876), Dangeard (1885, 1886), Constantineanu (1901), J. B. Butler and Buckley (1927), E. J. Butler (1928), Buckley and Clapham (1929), and J. B. Butler and Humphries (1932) from a wide range of host tissues, including eelworms, liverfluke ova, rotifer eggs, infusorial cysts, algae, and artificial media. However, no extensive study of its host range has yet been made, but the diversity of tissue on which it has been reported suggests at least that it may be very widespread. The fact that the species isolated from *Panicum variegatum* occurs also on eelworms, rotifer eggs, infusorial cysts and algae indicates a close relationship if not exact identity.

STRUCTURE AND BEHAVIOR OF THE ZOÖSPORES

The zoöspores of *Catenaria* sp. are produced in great abundance and thus offer exceptional opportunity for study of the problems of structure, germination and fusion. In many mounts of onion root tissue the number of swarmspores has been so great that the surrounding medium was a seething mass of motile darting organisms. The zoöspores are somewhat elongated and oval, and the majority vary from 4 to 5×6 to $7.5\ \mu$ with a single cilium attached at the posterior end. As is shown in figures 1 to 10 the cilia are approximately four to five times the diameter of the

zoöspore body in length. As they escape from the sporangium the zoöspores are usually somewhat elongated (FIG. 5), and retain this shape in the active swimming stage, but towards the end

FIG. 1. Showing probable stages in the fusion of zoöspores and the subsequent behaviour of the zygote.

of the motile period become almost spherical. Under certain conditions they may become distinctly amoeboid in shape and movement (FIG. 6 to 10).

The active swimming period lasts approximately forty minutes in tap water and under room temperature and light conditions, but may often be shortened or extended beyond this time. The swimming movement is comparatively smooth, but the zoöspores may occasionally dart about. They may come to an abrupt stop, and then dart off rapidly in another direction. So far no evidence of diplanetism has been observed. The zoöspores may become temporarily inactive when confined in a narrow space, but they have never been found to round up, retract or lose their cilia, encyst and then become active again as in the Saprolegniaceae.

As the end of the motile period approaches the swarmspores tend to assume a spherical shape and become sluggish in their movement. They may shake and whirl about actively for a few minutes without making much headway, but the movement finally dwindles down to a faint shimmer and ceases altogether. According to my

observations the cilia are not retracted but drop off and may frequently be seen lying separate in the water. The majority of zoöspores degenerate rapidly, and during this process they increase considerably in diameter and become highly vacuolated. Figures 11 and 12 respectively show late degeneration stages of bi- and uniciliated zoöspores. Within 10 to 20 minutes after becoming inactive the membrane of the zoöspore is ruptured, and the contents are disseminated in the surrounding medium.

The internal structure and contents of the zoöspore body are difficult to determine with any degree of certainty in living material. No single large, glistening and highly refractive body or globule such as occurs in most of the chytrid zoöspores is visible. One or several opaque bodies may be present in the center or slightly displaced towards the posterior end. Frequently one of the bodies may be somewhat crescentic or elongated, as is shown in figures 1, 2, 3, 5, 6, and 8. They often appear to be in a more clear space or vacuole which extends backwards to the point where the cilia are attached and seems to have some relation with it as described by E. J. Butler for *C. Anguillulae*.

The zoöspores are predominantly uniciliated, but biciliated and even triciliated forms have been observed. Figure 3 shows a triciliated zoöspore which measures 12 μ in diameter. Two of the cilia are attached at one point, while the third is slightly displaced. In figure 4 is shown a biciliated individual which is almost twice the size of the normal spore illustrated in figure 1. Size differences, however, are not always correlated with the number of cilia, since, as is shown in figure 3, uniciliated zoöspores may sometimes be as large as the biciliated ones.

Two cases of fusion between zoöspores or gametes have been observed to date. Up to the present time no fusions have been described for the genus *Catenaria*, and the two cases observed in *Catenaria* sp. thus bring the genus in line with *Olpidium*, *Synchytrium*, and other chytrids in which fusion between zoöspores or motile isogametes has been reported. In text figures 1 to 7 are shown progressive stages of fusion and the subsequent behavior of the zygote. The zoöspores or gametes continued to swim about slowly as fusion progressed (TEXT FIG. 2), and finally formed a zygote such as is shown in text figures 3 and 4. The two cilia,

however, remained widely separated, and the gametes appeared to retain their individuality to a marked degree. The zygote never became perfectly round as in *Olpidium* and *Synchytrium*

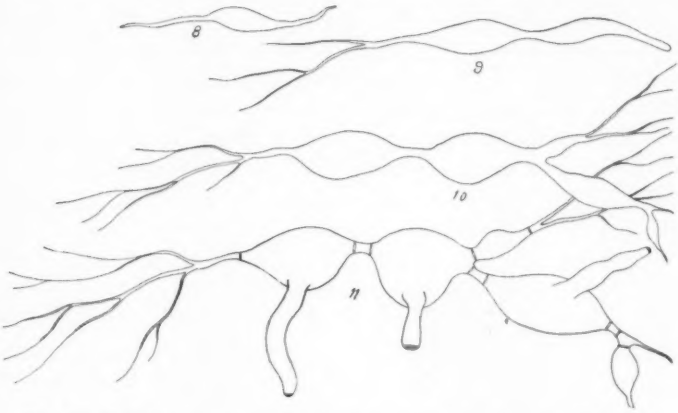


FIG. 2. Showing stages in the development of a polycentric thallus.

but remained more or less lobed. Furthermore, the denser more opaque bodies contributed by each gamete were quite distinct in size and number and their fate could readily be followed in the process of fusion. Gamete *A*, for instance, contained three bodies of different sizes, while *B*, had a single large slightly constricted one. These bodies never fused, but retained their identity as long as the zygote was kept under observation.

The subsequent behavior of the zygote was unusually interesting. Apparently the union was not entirely congenial, since both gametes made repeated attempts to separate and free themselves. Shortly after the stage shown in text figure 4 the two lobes of the zygote began to move apart, carrying their opaque bodies and cilium with them as is illustrated in text figure 5. Long pseudopods were formed in the direction of movement, and as a consequence only a narrow protoplasmic isthmus was left between the two parts. In the meantime the two cilia were very active, beating back and forth, but more or less in unison; so that they rarely became entangled. Separation of the two lobes continued further, until the zygote was stretched out over a distance of 32 μ, as is shown

in text figures 6 and 7. The connecting isthmus was drawn out to a fine strand measuring less than ½ μ in diameter, and in the process one of the cilia became stranded on the isthmus almost midway between the lobes. Failing to separate the two gametes slowly came back together, and again appeared very much like text figures 5 and 2. Separation was again attempted and repeated twice. Finally the zygote assumed the shape shown in text figure 4 and swam away. It thus became impossible to keep it in the field of observation for more than an instant, and I was unable to determine whether separation was eventually completed. Somewhat similar changes in shape and behavior were observed in the second case of fusion also.

In light of Cotner's (1930) studies on the development of zoöspores in the Oömycetes, the presence of numerous biciliated and occasional triciliated individuals is not to be taken, it seems to me, as conclusive evidence of sexual fusion in every case. Incomplete cleavage and the formation of unusually large segments may readily lead to the development of biciliated and triciliated zoöspores without involving fusions. Zoöspores with supernumerary cilia have been observed and described in many fungi in which no fusion of motile gametes has been seen. In *Physoderma Zeae-Maydis*, for instance, Miss Ojerholm (1934) reports that approximately one per cent of the swarmspores are biciliated, and yet few unmistakable cases of fusion could be found. The literature in relation to supernumerary cilia and fusion of motile isogametes among the chytrids has been adequately summarized by Miss Ojerholm.

DEVELOPMENT OF THE THALLUS

The majority of zoöspores degenerate shortly after coming to rest, and so far only two cases of germination have been directly observed. However, the epidermal cells of onion roots are frequently filled with small thalli, which indicates that a large proportion germinate. In figure 13 are shown two of the germination stages observed. At the left is a zoöspore lying on the host cell wall, and on the right is one which has partially penetrated. Complete entrance of this individual was not observed, so that it is impossible to say whether or not its entire content moved

bodily through the host cell wall. The stage here shown is quite different from that figured by Dangeard and J. B. Butler and Humphries for *C. Anguillulae* outside of the host cell and on artificial media; but strikingly similar to J. B. Butler's and Buckley's figures of germination on the ova of the liverfluke.

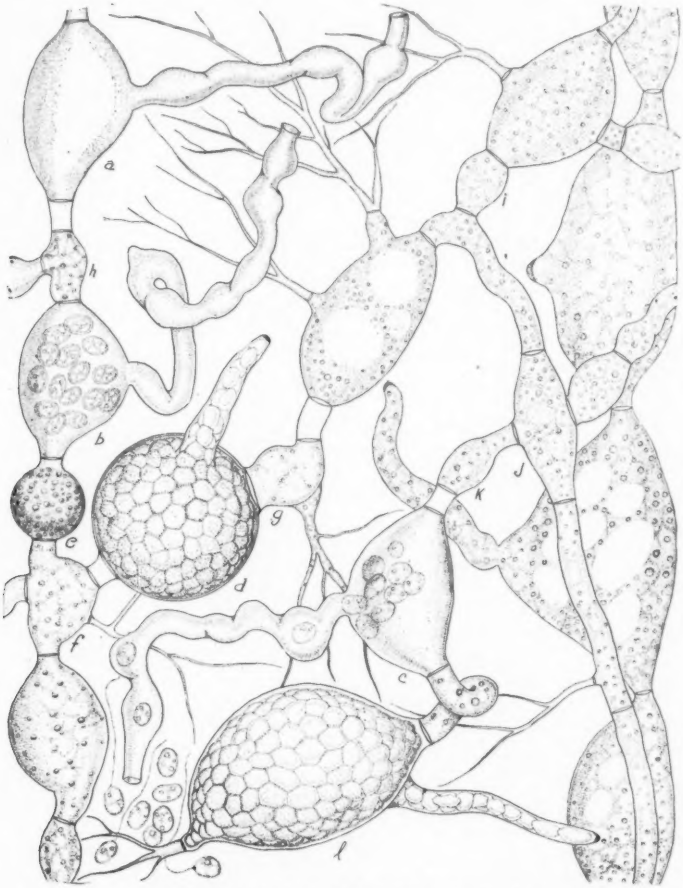


FIG. 3. A large extensively branched thallus elongated to a distance of 3.2 mm. in the degenerating pith of *Panicum variegatum; a, b, c,* zoösporangia with greatly elongated necks; *d* and *e,* zoösporangia with cleavage segments; *f, g, h, i, j,* and *k,* enlargements on the thallus apart from the zoösporangia.

The thallus of this species, like *C. Anguillulae,* exhibits without doubt the greatest range of variation in size, shape and organization of any known chytrid. The thalli may be unicellular, spherical, globular, elongated, and irregular without any trace of rhizoids (FIG. 14, 15, 22, 23) like species of the Olpidiaceae; monocentric with one to several rhizoids (FIG. 17, 18, 19, 24) as in the Rhizidiaceae, or multicellular, extensive, polycentric in organization and definitely mycelium-like (FIG. 20, 25, 26, 32) as in members of the Cladochytriaceae and higher fungi. It thus shows all the various types of organization that are found in the whole order of chytrids (Karling, 1932), but the multicellular polycentric habit of growth and development is predominant. All of these types of thalli have been found in onion roots, so that they are not to be regarded as the result of differences in the particular host in which they are growing. The general tendency, however, is for the thalli to be more rounded, condensed and less extensive in insect eggs, and more mycelium-like and extended in the long internodal cells of the Characeae. In *C. Anguillulae* Dangeard likewise observed reduced monocentric thalli which might readily be mistaken for a species of *Olpidium,* and on this basis he questions the validity of Braun's *O. endogenum* and Nowakowski's *O. gregarium* and suggests that in some cases they may only be a form of *C. Anguillulae.*

In figures 14 and 15 are shown two young spherical thalli from epidermal cells of *Allium Cepa* in which rhizoids are completely lacking. Several such thalli of this nature have been observed to grow to maturity and produce normal zoöspores. Figure 22 shows a spherical thallus with a well developed sporangial neck. In such individuals the entire thallus at maturity is transformed into reproductive cells and thus becomes monogeocentric as in *Olpidium* and other members of the Myxochytridineae. The thallus shown in figure 23 is quite irregular and under low powers of magnification superficially resembles a large amoeba.

Early developmental stages of monocentric thalli with one to several rhizoids are shown in figures 16 to 18. The one illustrated in figure 16 was followed to maturity in a bit of onion root epidermal tissue mounted in a hanging drop chamber. The two rhizoids developed extensively and produced several branches,

while the incipient sporangium became spherical with maturity. Figure 19 shows another similar thallus with two rhizoids. The contents of the sporangium has undergone cleavage into zoöspore segments, and a well defined sporangial neck is present. The rhizoids are very thick at their point of origin on the surface of the sporangium, 2.5 μ to 7 μ, and are separated from it by cross walls. This latter characteristic is perhaps the most essential difference between the monocentric thalli of *Catenaria* sp. and those of the Rhizidiaceae. In the majority of species of this family, as far as the evidence in the literature goes, the rhizoids are continuous with the remainder of the thallus at maturity and no septa are formed. In figure 24 is shown a thallus with a highly branched system of rhizoids which extended for a distance of 320 μ among the host cells. This compares favorably in extent and size with the rhizoidal systems of *Entophlyctis* and *Diplophlyctis* (Karling, 1928, 1931) which without doubt represent the maximum of rhizoidal development in the known rhizidiaceous forms. At the point where they pass through the host cell they are usually somewhat constricted, but this depends to a large extent on the state of degeneration of the host tissue.

The incipient sporangium in monocentric as well as polycentric thalli may become extensively developed in size and shape and ramify several host cells. The sporangial portion of the thalius shown in figure 24 has budded out and entered six adjacent cells, three lying above and four beneath. These lobes were all in continuity at the time the drawing was made, but at maturity septa were formed between them, making thus seven distinct sporangia. In one case observed a single sporangium had budded out and penetrated fourteen adjacent host cells, producing a more or less cluster of rounded lobes.

The early development of polycentric thalli is not essentially different from that of monocentric ones, as far as my observations go, with the exception that they are usually more elongated. In text figures 8 to 11 are shown stages in the development of such a thallus under hanging drop condition in room light and temperature. The development here figured for *Catenaria* sp. is strikingly like that reported by Dangeard, J. B. Butler, and Buckley, E. J. Butler and J. B. Butler for *C. Anguillulae*.

A partially mature polycentric thallus with eight incipient sporangia is shown in figure 20. Cross walls have been formed between the sporangia, but the rhizoids are still continuous with them. These were likewise later delimited by septa. The sporangia in this thallus remained long and cylindrical throughout and never became spherical. In the long internodal cells of various species of *Nitella* and *Chara* the thallus became markedly mycelium-like and extended in some instances for more than 2.5 mm. Two such thalli are shown in figures 25 and 26. Cross walls in such cases are numerous throughout the entire length, and rhizoidal development is somewhat attenuated. At maturity the sterile cells between the sporangia usually become empty and play no part in reproduction. In certain regions they may be very fine and not more than 3 μ in diameter.

The most extensive thallus so far observed is partially shown in figure 3. It extended for a distance of 3.2 mm. in the soft degenerating inner cortex of a *Panicum variegatum* root, and had numerous long side branches. Twenty-two sporangia of various sizes and shapes were distributed at irregular intervals along the thallus together with numerous enlargements from which side branches arose. Such thalli, however, are not remarkable and unusual in the *Catenariae*. J. B. Butler and Humphries have figured a thallus of *C. Anguillulae* growing on artificial media which was composed of more than two hundred and seventy sporangia. It is not certain, however, from their drawing that all of these constitute a single thallus.

STRUCTURE, SIZE AND SHAPE OF THE SPORANGIA

The shape and size of the sporangia are so variable that it is almost impossible to give representative drawings and measurements. They may be irregular, amoeboid, oval, cylindrical and spherical in shape. The spherical sporangia at maturity vary from 12 to 64 μ in diameter, while the cylindrical ones may be less than 7 μ in width and 160 μ in length. The range of variations in size and shape is very similar to that of *C. Anguillulae* described by J. B. Butler and Buckley, E. J. Butler, and J. B. Butler and Humphries. The exit canals or necks of the sporangia are quite variable in length and diameter. When growing in the inner cortex

of roots the necks may be as much as 250 μ in length and unusually irregular as is shown in figures 31, 32*a*, *b*, and *c*. This irregularity in diameter appears to be largely due to the fact that where they pass through the host walls they become constricted in the same manner as the rhizoids and the remainder of the thallus. When the sporangia lie in the epidermal cells the necks are more or less uniform in diameter and often no more than 10 μ in length. Upon reaching the surface of the host tissue they usually grow a few microns beyond as is shown in figure 22*a*. At the tip or apex is a slightly denser cap which appears to be universally present but is difficult to observe clearly in living material. E. J. Butler has reported a similar thickening of the apex in *C. Anguillulae*. Whether or not there is an operculum or lid present which is pushed off as the zoöspores escape is uncertain, since I have yet failed to observe the initial opening of a sporangium.

In view of the fact that the majority of species of the family Cladochytriaceae in which *Catenaria* has generally been placed have distinct enlargements on the rhizomycelium apart from the sporangia, special attention has been given to the presence of such structures in *Catenaria* sp. These enlargements are particularly conspicuous in *Cladochytrium, Physoderma* and *Urophlyctis,* vary considerably in size and shape, and have been given a variety of descriptive names. In a previous paper (1932) the author questioned the presence of " sammelzellen " or turbinate organs in the genus *Catenaria,* and pointed out that the particular host tissues in which they have been studied were not particularly favorable for their demonstrations. The long internodal cells of *Chara* and *Nitella* allow perhaps the maximum extension of the thallus of *Catenaria* sp. without crowding, and such host plants have been employed and carefully studied for the problem of " sammelzellen " in this genus. In studying such structures, however, only mature thalli have been used, since in immature ones they are indistinguishable from incipient sporangia. Under such conditions enlargements of the thallus have been found which vary in size and shape and do not always develop into sporangia. In figure 27 is a simple spindle-shaped body from a mature thallus which was devoid of content and closely resembled the unicellular collection cells of *Cladochytrium* (Karling, 1931). Additional enlargements

are shown in figures 28, 29 and 30 and at *d, e, f,* and *g,* figure 32. The ones drawn in figures 28 and 29 have given rise to several thallus branches and thus appear to be centers of duplication. No septate enlargements as in *Cladochytrium* have so far been found, and as a general rule they look more like the swellings on the thallus of *Hyphochytrium infestans* described by Zopf (1884). However, in spite of their occasional presence in *Catenaria* sp. the author is not inclined to regard them as centers of replication as in *Urophlyctis* (Jones and Dreschler, 1920). The enlargements shown in figures 27 to 30 may possibly be nothing more than incipient zoösporangia which failed to mature. Figure 21 shows a center with five radiating branches which resembles figure 28 with the exception that it has developed into a zoösporangium and formed a long exit tube. It is to be noted in this connection that J. B. Butler and Humphries failed to find definite " sammelzellen " in *Catenaria Anguillulae,* while growing extensively on artificial media.

In all of my observations to date the zoöspores become active in the zoösporangium, but due to crowding and pressure they appear merely to glide upon one another. After part of the mass has escaped the remaining ones become increasingly active, and the cilia become visible. If the neck becomes obstructed the content of the zoösporangium becomes a churning mass of swarmspores endeavoring to escape. In all sporangia observed the zoöspores emerged one by one and immediately swam away.

SUMMARY

1. *Catenaria* sp. was isolated from sterilized roots of *Panicum variegatum* which had been placed in a battery jar containing *Eriocaulon septangulare,* and appears to be a saprophyte capable of growing on a wide variety of dead tissue. It has been grown successfully in plant and animal tissues including nematodes, insects, algae, mosses, ferns, and angiosperms.

2. The thallus may be mono- or polycentric in organization, structure and development. Unicellular, spherical, oval and cylindrical thalli without any trace of rhizoids or vegetative parts as in the Myxochytridineae are not uncommon, and at maturity are transformed wholly into reproductive cells. Monocentric thalli

with one to several rhizoids as in the Rhizidiaceae are frequently produced. The predominant type of thallus, however, is polycentric with numerous zoösporangia, rhizoids, and enlargements scattered irregularly along its length.

3. In insect eggs the thallus is usually condensed and crowded, but in soft meristematic plant tissues and the internodal cells of *Chara* and *Nitella* may become distinctly mycelium-like and extend to a length of 3.2 mm. The thallus is unicellular and continuous when young, but at maturity becomes multicellular by the formation of numerous cross walls along its length. The rhizoids are likewise separated from the remainder of the thallus by septa at maturity.

4. The zoösporangia are extremely variable in size and shape, ranging from spherical, oblong, cylindrical, amoeboid, irregular to star-shaped. Occasional enlargements occur in the thallus which may or may not develop into zoösporangia and resemble somewhat the " sammelzellen " of *Physoderma* and *Cladochytrium*. Whether or not they are to be regarded as such and occasionally serve as centers of replication is uncertain.

5. Zoöspores are produced in great abundance and vary considerably in size. They are predominantly uniciliated, but numerous biciliated and occasional triciliated ones occur. Two cases of fusions between zoöspores or gametes have been observed.

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LITERATURE CITED

Buckley, J. J. C., & P. A. Clapham. The invasion of helminth eggs by chytridiacean fungi. Jour. Helminth. **7**: 1–14, *pl. 1.* 1929.

Butler, J. B., & J. J. C. Buckley. *Catenaria Anguillulae* as a parasite of the ova of *Fasciola hepatica.* Sci. Proc. Roy. Dublin Soc. **18**: 497–512, *pl. 23–26.* 1927.

——, **& A. Humphries.** On the cultivation in artificial media of *Catenaria Anguillulae,* a chytridiacean parasite of the ova of the liver fluke, *Fasciola hepatica.* Sci. Proc. Roy. Dublin Soc. **20**: 301–324, *pl. 13–18, fig. 1–2.* 1932.

Butler, E. J. Morphology of the chytridiacean fungus, *Catenaria Anguillulae,* in liver fluke eggs. Ann. Bot. **42**: 813–821, *fig. 1–19.* 1928.

Constantineanu, J. C. Contributions a la flore mycologique de la Roumaine. Rev. Gen. Bot. **13**: 368–389, *fig. 76–84.* 1901.

Cotner, F. B. The development of the zoöspores in the Oömycetes at optimum temperatures and the cytology of their active stages. Am. Jour. Bot. **17**: 511–546, *pl. 30–33, fig. 1.* 1930.

Dangeard, P. A. Note sur le *Catenaria Anguillulae*, Sorok. *Chytridium zoötocum*, A. Br. Bull. Soc. Linn. Normandie III. **9**: 126–135, *pl. 1.* 1885.

——. Recherches sur les organismes inférieurs. Ann. Sci. Nat. VII. **4**: 241–341, *pl. 11–14.* 1886.

Jones, F. R., & C. Dreschler. Crownwart of alfalfa caused by *Urophlyctis Alfalfae*. Jour. Agr. Res. **20**: 295–324, *pl. 47–56.* 1920.

Karling, J. S. Studies in the Chytridiales. II. Contribution to the life history and occurrence of *Diplophlyctis intestina* (Schenk) Schröter, in cells of American Characeae. Am. Jour. Bot. **15**: 204–214, *pl. 14, fig. 1–2.* 1928.

——. Studies in the Chytridiales. V. A further study of species of the genus *Entophlyctis*. Am. Jour. Bot. **18**: 443–463, *pl. 35–38, fig. 1–54.* 1931.

——. Studies in the Chytridiales. VI. The occurrence and life history of a new species of *Cladochytrium* in cells of *Eriocaulon septangulare*. Am. Jour. Bot. **18**: 526–557, *pl. 42–44.* 1931.

——. Studies in the Chytridiales. VII. The organization of the chytrid thallus. Am. Jour. Bot. **19**: 41–74, *fig. 1–138.* 1932.

Ojerholm, E. T. Multiciliate zoöspores in *Physoderma Zeae-Maydis*. Bull. Torrey Club **61**: – . 1934.

Sorokin, N. Note sur les vegetaux parasites des Anguillulae. Ann. Sci. Nat. VI. **4**: 67–71, *pl. 3.* 1876.

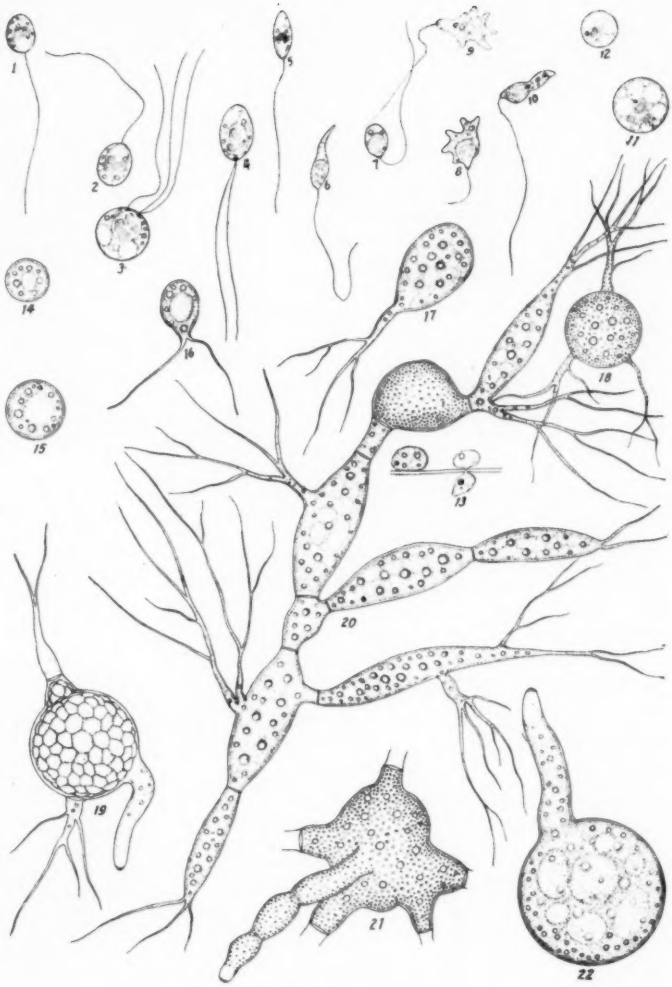
Zopf, W. Zur Kenntniss der Phycomyceten. 1. Zur Morphologie und Biologie der Ancylisteen und Chytridiaceen, zugleich ein Beitrag zur Phytopathologie.

DESCRIPTION OF PLATES

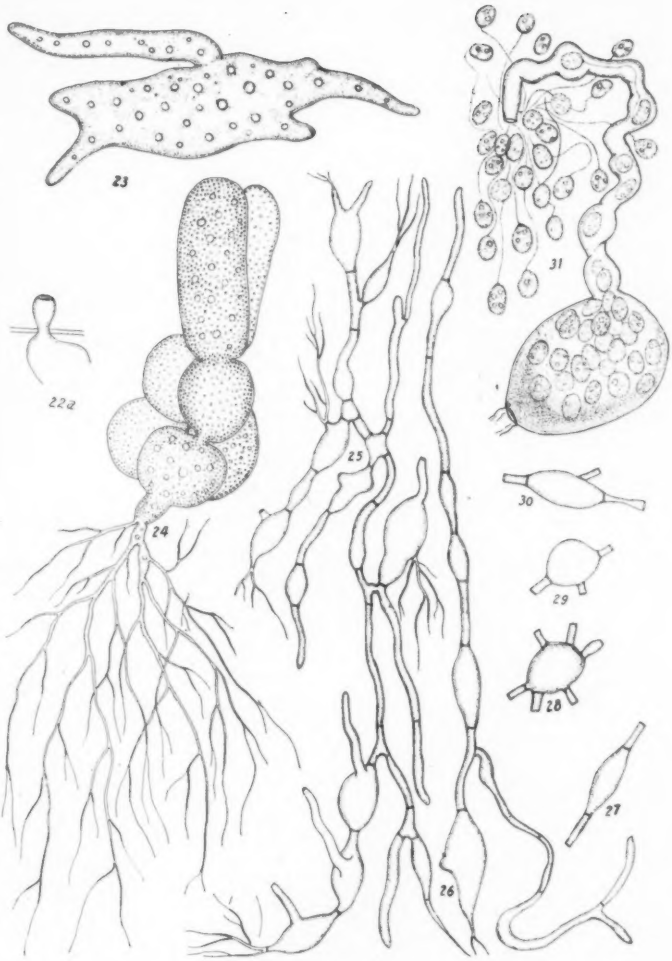
All drawings were made from living material with the aid of a Spencer camera lucida and a Zeiss 1.30 N. A. apochromatic objective and compensating oculars nos. 6 and 8. Unless otherwise indicates all drawings are from *Allium Cepa*.

PLATE 57

Fig. 1, A normal-sized uniciliated zoöspore with one large somewhat crescentric body in the center; 2, A large uniciliated zoöspore; 3, A large triciliated zoöspore measuring 12 μ in diameter; 4, A biciliated zoöspore approximately twice the size of a normal uniciliated individual; 5, Zoöspore at the time of escape from the zoösporangium; 6, Elongated zoöspore in the process of escaping from a confined area; 7, A small uniciliated zoöspore; 8, 9, Amoeboid changes in shape and movement of zoöspores in confined quarters; 10, Constricted zoöspore; 11, 12, Late degeneration stages of bi- and uniciliated zoöspores; 13, Early infection stages on epidermis of *Allium Cepa;* 14, 15, Young spherical monocentric thalli lacking rhizoids; 16, 17, Young monocentric thalli with rhizoids; 18, Small, spherical mono-



CATENARIA ANGUILLULAE



CATENARIA ANGUILLULAE

centric thallus with three rhizoids; 19, A large mature monocentric thallus with two rhizoids and a well developed neck. The content has undergone cleavage; 20, Immature, polycentric, septate thallus from pith of *Panicum variegatum* with eight incipient zoösporangia and numerous rhizoids; 21, An irregular, somewhat star-shaped zoösporangium developed at the intersection of several thallus branches; 22, A large, spherical, almost mature monocentric thallus lacking rhizoids; 22*a*, Neck of a sporangium projecting slightly beyond the host cell wall and somewhat thickened at the apex.

PLATE 58

Fig. 23, An irregular, amoeboid-shaped monocentric thallus with three well developed exit tubes; 24, A large monocentric thallus with an extensive rhizoidal system. The incipient zoösporangium has budded out into six adjacent host cells; 25, An extensive mycelium-like polycentric thallus from internodal cells of *Nitella flexilis;* 26, An elongated thallus from internodal cells of *Chara coronata;* 27–30, Variously shaped, unicellular enlargements of the thallus; 31, Zoösporangium from the pith of *Panicum variegatum.* Sporangial neck twisted and irregular in shape and diameter.

THE AMERICAN AND JAPANESE MATSU-TAKES[1]

S. M. Zeller and K. Togashi

(with 6 text figures)

Along the Pacific slope of Oregon and Washington occurs a species of *Armillaria* which is assiduously collected by Japanese residents for commercial purposes. These local people have applied the name "Matsu-take" (pine mushroom) to this American species as they had applied it to one of the choice mushrooms

Fig. 1. Showing the general habitat of *Armillaria matsutake* in its association with *Pinus densiflora*, Suzukawa-mura, Prefecture Yamagata, Japan, October 16, 1932. Photo by Unya Kato.

(*Armillaria matsutake* Ito & Imai) of Japan. Many of the Japanese who reside in Oregon and collect the American Matsu-

[1] Published as Technical Paper No. 215 with the approval of the Director of the Oregon Experiment Station. Contribution from the Department of Botany in coöperation with the Department of Plant Pathology, Morioka Imperial College of Agriculture and Forestry, Morioka, Japan.

take, hold to the opinion that it is identical with the Matsu-take with which they were familiar in their native land. For a number of years we on the Pacific Coast have been interested in a more exact understanding of the taxonomy of the western species and its possible con-specific relationship with the Matsu-take of Japan. In order that we might reach such an understanding the authors have exchanged herbarium collections of the two forms from various locations, together with more or less critical notes, photographs, etc. It is the purpose of this paper to bring together notes that might be of general interest to mycologists, and to show the close relationship between the two Matsu-takes.

THE JAPANESE MATSU-TAKE

A complete discussion of the taxonomy of the Japanese *Matsu-take* has been published by Ito and Imai.[2] Since 1878 when Berkeley[3] described *Shii-take* (*Cortinellus Berkeleyanus* Ita & Imai) as *Armillaria edodes* several European, Japanese, and American taxonomists have taken the liberty to propose a binomial for either *Matsu-take* or *Shii-take*. Ito and Imai found by studying collections in European herbaria that names had been so jumbled between the two fungi that it seemed necessary to give each a new name. Matsu-take accordingly in Japan now goes under the name

ARMILLARIA MATSUTAKE Ito & Imai, Bot. Mag. (Tokyo) **39**: 327. 1925.

Fructifications gregarious or cespitose, sometimes single, large, 10–16 cm. high; *pileus* 8–20 cm. broad, thick, firm, hemispherical then expanding, convex to broadly or almost placo-umbonate; *surface* dry (to slightly subviscid in fresh condition) easily stained by clay-like soils, dull when dry, fibrous scaly, often fissured radially toward the margin, sepia tones, disk becoming tawny, russet or Mars brown,[4] fibrils concolorous with disk (drying

[2] Ito, S., and S. Imai. On the taxonomy of Shii-take and Matsu-take. Bot. Magazine (Tokyo) **39**: 319–328. *Pl. 6.* 1925.

[3] Berkeley, M. J. Enumeration of the fungi collected during the expedition of H. M. S. "Challenger," 1874–1875. Jour. Linn. Soc., Bot. **16**: 38–54. 1878.

[4] Ridgway's Color Standard was used as an aid in the descriptions.

chestnut-brown to mummy-brown or even blackish-brown in very old specimens); *margin* inrolled under the slightly persistent veil, only slightly lighter than the disk; *flesh* white to cremeous, firm

FIG. 2. *Armillaria matsutake* collected at Iwate-gun, Prefecture Iwate, Japan, October, 1932. Photo by K. Togashi. $\times \frac{1}{5}$.

with an especially agreeable (spicy) *odor* and *taste; gills* sinuate or adnexed, usually breaking free at maturity, close, 10–12 mm. broad, whitish changing buff at maturity; *spores* white, smooth, broadly ellipsoidal, 1-guttulate, 3–8 $\times$ 3–6 μ (5.57 $\pm$ 0.02 $\times$ 4.40 $\pm$ 0.01 μ), mature spores appendiculate; *stem* 10–15 cm. long, 1.5–4 cm. thick, sub-equal or tapering upward, sometimes with

enlarged base, coated by the fibrillose scaly veil and concolorous with pileus below the annulus, whitish and smooth or innately fibrillose above; *annulus* ample, persistent, membranous (at first cortinate-membranous at margins), sometimes sheathing or fluted upward, superior.

Usually in soil of the Chichibu palaeozoic type or decomposed granite. Usually associated in a mycorrhizal relationship with *Pinus densiflora* on the main island (Honshu) of Japan. September to November; sometimes August, especially in the northern districts.

Ecology of Armillaria matsutake.—According to Masui [5] the Japanese Matsu-take is an obligate mycorrhiza-former on *Pinus densiflora.* The fructifications thus may originate without any direct connection with humus in the soil but merely from an interwoven network of mycelium projecting from numerous mycorrhizas on the roots of the host. For the most part, therefore, mushroom hunters in Japan look for Matsu-take under *Pinus densiflora,* since they realize that the living roots of this tree play an essential rôle in the production of this mushroom. Masui cites cases where no mushrooms occur in certain places the year after pine trees were cut. If the main roots only are cut Matsu-take does not appear from the soil where rootlets of cut trees are distributed. Living roots of a host tree must be present for the production of Matsu-take.

It seems, however, that occasionally Matsu-take is associated with other trees. Most of the specimens cited below were collected under the Japanese Red-Pine (*Pinus densiflora*) but the specimens from South Saghalien were found under Abies sp. according to Mr. T. Ishiyama, Botanical Institute, Agricultural Department, Hokkaido Imperial University, Sapporo. Through the courtesy of Mr. Ishayama we obtained the Saghalien material collected by a ranger of the Tomarii Forestry Station. Dr. S. Kawamura [6] says Matsu-take often grows under fir trees (*Abies firma* Sieb. & Zucc.) even in the main island of Japan and the Taiwan strain

[5] Masui, K. A study of the ectotrophic mycorrhizas of woody plants. Kyoto Imp. Univ., Coll. of Sci., Memoirs (Series B) **3**: 149–279, *illus.* 1927.

[6] Kawamura, S. Explanatory diagrams of Japanese mushrooms, Tokyo, 1929. (Japanese.)

of Matsu-take from the Island of Formosa (cited below) occurs under Niitaka Red-Pine trees (*Pinus taiwanensis* Hayata) according to Sawada.[7] He describes this Formosan (Taiwan)

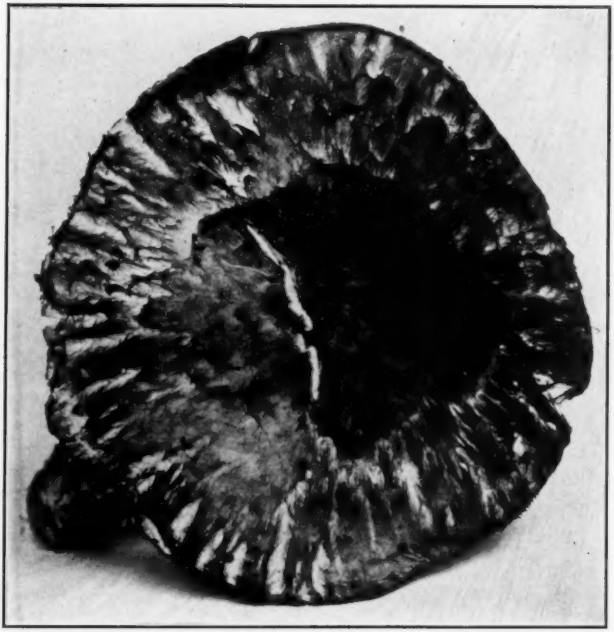


FIG. 3. *Armillaria matsutake* showing the characters of the upper surface of the pileus, collected at Kasugabe, Prefecture Hyogo, Japan, October, 1932. Photo by E. Togashi. × ⅘.

material as differing somewhat from that of the main island, *i.e.*, it has more delicate and fewer fibrils and consequently the pileus is lighter in color, the basidia are longer with only 2 sterigmata in most cases, and the spores are more oily.

In Japan several Hymenomycetes occur under the same ecological conditions and in association with the Japanese Red Pine. In the central and southern districts of Honshu *Cortinarius elatior, C. cinnamomeus, Armillaria caligata, Boletus bovinus, Cantherellus*

[7] Sawada, S. Descriptive catalog of the Formosan fungi. Part V, p. 90. 1931.

floccosus, and *Rhizopogon rubescens* are to be mentioned in this relation. *R. rubescens* develops a little later than the others, continuing its production to the next spring. While in the northern districts of Honshu *Boletus bovinus, B. elegans,* and *Armillaria caligata* are the essential associators of *A. matsutake.*

Specimens of *Armillaria matsutake* from the Japanese Empire examined by both authors:

South Saghalien: Tomarii, Sept. 20, 1932 (sent by *T. Ishiyama*).
Honshu: Pref. Iwate, Kadoma, *Kogo Togashi,* Oct. 11, 1932, Shimohei-gun, *K. Togashi,* Oct. 10, 1932 (last two collections taken at market of Morioka city); Pref. Gifu, *Makoto Hiura,* Oct. 12, 1932 (taken at market of Gifu city); Pref. Osaka, Minomo, *Yasuhiko Sato,* Oct. 23, 1932; Pref. Hyogo, Goyu, *Y. Sato,* Oct. 6, 1932, Kasugabe, *Y. Sato,* Oct. 12, 1932; Pref. Yamaguchi, Asa, *Fukundo Monde,* Oct. 23, 1932.
Formosa: Niitaka-gun, Banaiko, *Takuji Kato,* Sept. 25, 1932 (sent by *F. Onuma*).

THE AMERICAN MATSU-TAKE

The "Pine-mushroom" or "Japanese mushroom" as it is called along the Pacific Coast of Oregon and Washington was first described from this region by Murrill[8] as *Armillaria arenicola.* The late Dr. Kauffman[9] made collections at Hoodsport, Mason County, Washington, where it occurred "common enough to be assiduously collected by Japanese for commercial purposes." He said further, "I have referred this collection to *A. arenicola,* but except for the recorded accounts of the spores of *A. ponderosa,* it could be just as well referred to the latter."

Burt[10] says of *Armillaria ponderosa* that "Peck published the spores as globose, 4 μ in diameter, but they are more elongated in the Vermont specimens, determination of which was confirmed by Peck, and also in the New Brunswick (Canada) gathering" illustrated in the Icones (*pl. 13*). In the description Burt gives the spores as "white, even, 6–7 $\times$ 4–5 μ." Murrill's description

[8] Murrill, W. A. The Agaricaceae of the Pacific Coast, I. Mycologia **4**: 212. 1912.

[9] Kauffman, C. H. The genus *Armillaria* in the United States, and its relationships. Mich. Acad. Sci. Papers **2**: 53–67, *illus.* 1922.

[10] Farlow, W. G., & E. A. Burt. Icones Farlowianeae, *p. 15.* 1929.

of the Pacific Coast form gives "spores globose, smooth, hyaline, 4–6 μ." He also says "In general appearance, it resembles *Armillaria magnivelaris* Peck," commonly recognized as a synonym of *A. ponderosa* Peck. The collection of *A. magnivelaris* taken at Copake, N. Y., October, 1872, by Chas. H. Peck, seems identical with the western material. All of the spore measurements published for the eastern and western material can be easily included in our measurements given below for the Florence gathering in particular. This gathering of more than 200 specimens gave a very wide range in sporophore development and the range of spore measurements was quite inclusive. We feel little hesitancy in suggesting the below synonymy and adopting *Armillaria ponderosa* (Peck) Sacc. as the name of the Pacific Coast form.

The agreeable, slightly spicy odor of the western plant is difficult to describe accurately, but it is unmistakably distinctive. Some have described it as spicy, while others think it similar to the odor of sandal wood.

The synonymy of the American Matsu-take is as follows:

ARMILLARIA PONDEROSA (Peck) Sacc. Syll. Fung. **5**: 58. 1887 (*Agaricus ponderosus* Peck, Bull. Buffalo Soc. Nat. Sci. **1**: 42. 1873);—*Agaricus magnivelaris* Peck, Ann. Rept. N. Y. State Mus. **29**: 66. 1878;—*Armillaria magnivelaris* (Peck) Murrill, N. Am. Fl. **10**: 37. 1914;—*Armillaria arenicola* Murrill, Mycologia **4**: 212. 1912.

Fructification mostly single, often gregarious, sometimes cespitose, very large, 10–15 cm. high; *pileus* 8–21 cm. broad, thick, firm, convex or broadly umbonate to gibbous, then nearly plane when expanded; *surface* dry to subviscid so that sand and conifer needles adhere slightly, shining to dull when dry, glabrous or becoming fibrillose (sometimes fibrous scaly after rains), at first white or pinkish buff, disk and fibrils becoming light ochraceous-salmon (liver brown, russet, or even Mars brown *in extreme cases*), fibrils concolorous with disk; drying pale ochraceous-buff to warm buff, fibrils tawny to russet; *margin* inrolled under the slightly persistent veil, white to cremeous, usually lighter than the disk; *flesh* white, firm, with an agreeable, somewhat spicy odor and taste; *gills* emarginate, becoming sinuate-adnexed, or break-

ing free at maturity, close to crowded, 8–12 mm. broad, whitish to light buff in young specimens becoming warm buff or even ferruginous, changing liver brown where bruised; *spores* white, smooth, subglobose to oblong, 1-guttulate, 4–7 × 3–5 μ (5.16 ± 0.01 × 4.17 ± 0.01 μ) *stem* 10–15 cm. long, 2–4 cm. thick, cylindrical or tapering downward, coated by the veil and same color as pileus below the annulus, changing rubescent to liver brown where bruised or exposed, scales below annulus more or less prominent, white and furfuraceous above the annulus; *annulus* ample, persistent, membranous (at first the margins cobwebby from the cortinate-membranous veil), sometimes sheathing or fluted upward, above the middle of the stem.

Usually in sandy locations. Although described as 10–15 cm. tall the plants may push but a few centimeters above the surface of the sand, exposing usually a small portion of the cap while the stem is buried deep in the sand. Usually in rather open pine barrens, but found under several genera of conifers. October to December on the Pacific Coast of Oregon and Washington, U. S. A. Quite abundant where found.

Ecology of Armillaria ponderosa.—Along the coast for the most part this fungus is found under *Pinus contorta* but around the base of Mt. Hood it is reported under other conifers, especially *Pseudotsuga taxifolia,* under which Mr. Ethan Allen, a resident of Waldron on Waldron Island, reports it from the San Juan Islands. He says on Waldron Island it also occurs under *Pinus contorta, Tsuga heterophylla,* and *Thuja plicata,* and often among such under-growth as *Gaultheria Shallon* and *Chimaphila umbellata.* Mr. Allen says *Armillaria ponderosa* always follows in the same type of locations where *Russula delica* had occurred about two weeks earlier. In the Florence district, Lane County, Oregon, this mushroom occurs under similar conditions as do *Armillaria robusta, Amanita muscaria, Boletus edulis,* and *Tricholoma equestre,* and *Rhizopogon occidentalis* and *R. rubescens. Boletus edulis* appears several weeks earlier. During November, 1933, rhizomorphic connections have been traced between the basidiocarps and ectotropic mycorrhizas on rootlets of *Pinus contorta* at Waldport, Oregon.

Specimens examined:

New York: Columbia Co., Copake, *Chas. H. Peck,* Oct., 1872 (type of *Armillaria magnivelaris* Peck, in N. Y. State Museum).

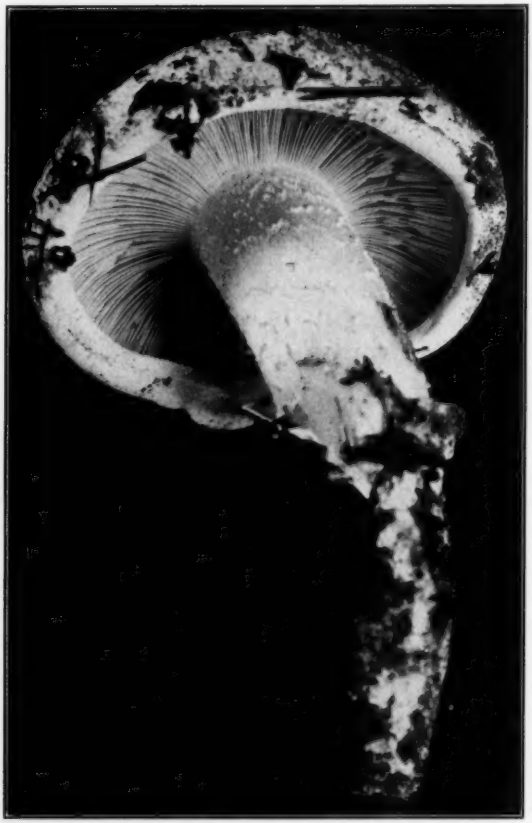


FIG. 4. *Armillaria ponderosa* collected north of Florence, Oregon, November 28, 1932. Photo by S. M. Zeller. ×¾.

Washington: Clellam Co., near Port Angeles, *J. W. Hotson,* Autumn, 1930 (in Univ. Wash. Herb.); Kitsap Co., Bainbridge Island, *J. W. Hotson,* Oct., 1926 (in Univ. Wash. Herb.); San Juan Co., Waldron Island, *Ethan Allen,* Dec. 3, 1932; Whatcom Co., Dot Island, Chuckanut Bay, *Ethan Allen,* Dec. 5, 1932.

Oregon: Hood River Co., toward Mt. Hood above Parkdale, *Katzuko Konishi,* Oct. 22, 1931; Tillamook Co., Nehalem, *C. K. Ogura,* Oct. 2, 1932; Lane Co., near Florence, *Ralph Johnson,* Oct. 16, Nov. 10, 1932, *Mr.* and *Mrs. S. M. Zeller,* Nov. 28, 1932 (collection of over 200 specimens).

COMPARISON OF THE AMERICAN AND JAPANESE MATSU-TAKES

The particular question in connection with *Armillaria ponderosa* on the Pacific Coast is its taxonomic relationship to *A. matsutake* of Japan. The two must be very similar in gross external anatomy, odor, and taste, since the Japanese laymen on both sides of the Pacific Basin believe them to be identical. A few interesting comparisons may be drawn.

TABLE 1

BIOMETRIC DATA FOR LENGTH AND WIDTH OF 400 SPORES OF THE AMERICAN MATSU-TAKE, BASED ON 100 SPORES FROM EACH OF 4 DIFFERENT MATERIALS (IN μ)

Length

Material	Range	Mode	Mean	Standard deviation	Coefficient of variability
Z 5597.....	4.0–7.0	5.0	5.29 ± 0.03	0.58 ± 0.02	11.11 ± 0.53
Z 5595.....	4.0–6.0	5.0	4.93 ± 0.03	0.51 ± 0.02	10.44 ± 0.49
Z 8129.....	4.0–6.0	5.0	5.14 ± 0.03	0.49 ± 0.02	9.53 ± 0.45
Z 8030.....	4.0–7.0	5.0	5.30 ± 0.03	0.51 ± 0.02	9.80 ± 0.46
Total.....	4.0–7.0	5.0	5.16 ± 0.01	0.55 ± 0.01	10.65 ± 0.25

Width

Z 5597.....	4.0–5.0	4.0	4.30 ± 0.02	0.41 ± 0.01	9.58 ± 0.45
Z 5595.....	3.0–5.0	4.0	4.08 ± 0.01	0.27 ± 0.01	6.64 ± 0.31
Z 8129.....	4.0–5.0	4.0	4.16 ± 0.01	0.26 ± 0.01	6.32 ± 0.30
Z 8030.....	4.0–5.0	4.0	4.14 ± 0.01	0.26 ± 0.01	6.44 ± 0.30
Total.....	3.0–5.0	4.0	4.17 ± 0.01	0.32 ± 0.007	7.67 ± 0.18

Materials	Locality	Date	Collector
Z 5597..	Florence, Oregon	Nov. 28, 1932	S. M. Zeller
Z 5595..	Waldron Island, Washington	Dec. 3, 1932	E. Allen
Z 8129..	Lane County, Oregon	Oct. 16, 1932	R. Johnson
Z 8030..	Odell, Oregon	Oct. 22, 1931	K. Konishi

Color.—The American is lighter in color than the Japanese Matsu-take. The usual color of the fibrils and disk of *A. matsutake* when fresh is tawny, russet, or Mars brown, while in *A. ponderosa* it is usually pinkish buff or light ochraceous salmon. In very extreme cases of exposure to rain or direct sunlight after rain, very mature specimens of *A. ponderosa* may show as dark colors as *A. matsutake* usually exhibits. In these extreme cases the colors are almost exactly those of the latter. Figures 2, 4, and 5 show very well the degree of difference in color.

Surface of the pileus.—In *A. matsutake* the surface is characteristically fibrous scaly, the fibrils loose and easily disturbed by rubbing. On this account the surface is often fissured radially toward the margin. On the other hand the surface of *A. ponderosa*

TABLE 2

BIOMETRIC DATA FOR LENGTH AND WIDTH OF 400 SPORES OF THE JAPANESE MATSU-TAKE, BASED ON 100 SPORES FROM EACH OF 4 DIFFERENT MATERIALS (IN μ)

Length

Material	Range	Mode	Mean	Standard deviation	Coefficient of variability
T 1.....	3.0–8.0	6.0	5.85 ± 0.05	0.80 ± 0.03	13.75 ± 0.65
T 2.....	4.0–8.0	5.0	5.90 ± 0.06	0.95 ± 0.04	16.16 ± 0.77
T 3.....	4.0–6.0	5.0	5.20 ± 0.03	0.52 ± 0.02	10.17 ± 0.48
T 4.....	4.0–6.0	5.0	5.36 ± 0.04	0.60 ± 0.02	11.35 ± 0.54
Total.....	3.0–8.0	5.0	5.57 ± 0.02	0.80 ± 0.01	14.38 ± 0.34

Width

T 1.....	3.0–6.0	4.0	4.48 ± 0.03	0.53 ± 0.02	12.01 ± 0.57
T 2.....	3.0–5.0	4.0	4.35 ± 0.03	0.55 ± 0.02	12.74 ± 0.60
T 3.....	4.0–5.0	4.0	4.47 ± 0.03	0.49 ± 0.02	11.16 ± 0.53
T 4.....	4.0–5.0	4.0	4.30 ± 0.03	0.45 ± 0.02	10.65 ± 0.50
Total.....	3.0–6.0	4.0	4.40 ± 0.01	0.51 ± 0.01	11.80 ± 0.28

Materials	Locality	Date	Collector
T 1.....	Kadoma, Pref. Iwate	Oct. 11, 1932	From market of Morioka
T 2.....	Kadoma, Pref. Iwate	Oct. 13, 1932	From market of Morioka
T 3.....	Kasugabe, Pref. Hyogo	Oct. 12, 1932	Y. Sato
T 4.....	Minomo, Pref. Osako	Oct. 23, 1932	Y. Sato

is smooth, subviscid so that sand or soil cling, becoming innate fibrillose, but really becoming *fibrous scaly only after rains.*

FIG. 5. *Armillaria ponderosa* showing the breaking of the veil, collected north of Florence, Oregon, November 28, 1932. Photo by S. M. Zeller. ×¾.

Spores.—The spores of the two species are extremely close in shape and measurements as tables 1 and 2 clearly show. This biometric study of the spores of the two species indicates that there is no significant difference between spore sizes of the two, even

though the total spores of the Japanese form are somewhat larger than those of the American form.

In this connection a more or less irrelevant note concerning the variability of spore shapes and sizes in subsequent spore-prints from the same pileus may be of interest. Table 3 illustrates the

TABLE 3

BIOMETRIC DATA FOR LENGTH AND WIDTH OF EACH OF 100 SPORES FROM THE SAME PILEUS (*A. matsutake*) (IN MICRONS). MATERIAL: IWATE-GUN, PREF. IWATE, OCT. 11, 1932

Length

Date	Spore-print	3.0	4.0	5.0	6.0	7.0	8.0	Mean	St. dev.	Coeff. var.
Oct. 12	1st*	1	2	27	53	15	2	5.85 ± 0.05	0.80 ± 0.03	13.75 ± 0.65
Oct. 13	3rd	1	8	48	41	2	0	5.35 ± 0.04	0.69 ± 0.03	13.05 ± 0.62
Oct. 14	5th	1	7	45	42	5	0	5.43 ± 0.04	0.73 ± 0.03	13.59 ± 0.64
Oct. 16	9th	0	3	58	35	4	0	5.40 ± 0.04	0.61 ± 0.02	11.40 ± 0.54

Width

Oct. 12	1st	1	51	47	1			4.48 ± 0.03	0.53 ± 0.02	12.01 ± 0.57
Oct. 13	3rd	5	76	19	0			4.14 ± 0.03	0.46 ± 0.02	11.33 ± 0.54
Oct. 14	5th	1	64	35	0			4.34 ± 0.03	0.49 ± 0.02	11.38 ± 0.54
Oct. 16	9th	0	55	45	0			4.45 ± 0.03	0.49 ± 0.02	11.17 ± 0.53

* Printed twice a day.

point that especially the length of spores varies with maturity of the fructification. The tendency is toward slightly larger spores in the younger stages and somewhat smaller and rounder spores in the later spore-prints, where the variability of spore size also becomes narrower. This tendency toward rounder spores at maturity may partially explain Peck's, as well as Murrill's, observations of globose or subglobose spores in their descriptions (*A. ponderosa, A. magnivelaris,* and *A. arenicola*). This may also explain some of the variability in Table 2.

Ecology.—For the most part the ecology of the two species has been discussed above. It is of particular interest here to note, however, the difference in types of soil which favor the production of each. The Japanese Matsu-take seems to grow most favorably in the Chichibu palaeozoic or decomposed granite soils covered by a thick layer of forest duff and also on mountain slopes having

similar soils. It seldom, if ever, develops in sandy locations as does the American Matsu-take. On the main island (Honshu) of Japan *Pinus densiflora*, the living roots of which play an essential

FIG. 6. *Armillaria ponderosa* showing the characters of the surface of the pileus, collected near Florence, Oregon, Nov. 28, 1932. Photo by S. M. Zeller. $\times \frac{3}{4}$.

rôle in the production of Matsu-take (Masui, 1927), occurs rather commonly in sandy coastal plains, but Matsu-take is not collected in such locations. On the contrary *A. ponderosa* is found at its best and in quantity in the pine (*Pinus contorta*) barrens of the coastal sand dunes and in very sandy loams of the mountain areas (Mt. Hood). The types of hymenomycetous associates of the two are very similar, and both are ectotropic mycorrhizal fungi.

Both species are exceptionally palatable mushrooms, having a firm, fine texture and a distinctively good flavor. Both are highly prized by the Japanese people. Both species are good canners in the button stages, but lose their fragrance in the dried condition,

a sharp contrast with Shii-take (*Cortinellus*) which is used commonly as a dried food in Japan.

According to the usual taxonomic comparisons *Armillaria matsutake* and *A. ponderosa* differ but slightly, especially in morphological characters. They suggest the possibility that wide geographic separation and ecological conditions may produce variants such as these in a single species of Agarics and that it may be necessary in certain groups of the gill fungi to take into consideration certain ecological and physiological conditions in their final classification into species. In this case, however, after a consideration of all of the differences the authors feel that the two are perhaps specific entities.

INDEX TO VOLUME XXVI

INDEX TO AUTHORS AND TITLES

Ames, L. M. Hermaphroditism involving self-sterility and cross-fertility in the ascomycete *Pleurage anserina* 392

Aronescu, Alice. Further tests for hormone action in *Neurospora* 244

Arthur, J. C. Bartholomew's Handbook 108; Interpretation of rule 49 bis 471

Ayers, T. T. & **Hahn, G. G.** Dasyscyphae on conifers in North America. I. The large-spored white-excipled species 73; II. *D. Ellisiana* 167; III. *Dasyscypha Pini* 479

Beardslee, H. C. New and interesting fungi 253

Boyd E. S. A developmental study of a new species of *Ophiodothella* 456

Cash, E. K. *Godronia urceolus* and other Cenangiaceae on Ribes 266

Cherry, W. F. *Mycotypha microspora* isolated from *Chaenomeles legenaria* 133

Dodge, B. O. *Gymnosporangium myricatum* in relation to host parenchyma strands 181; A lethal for ascus abortion in *Neurospora* 360

——, **Stewart, F. C.** & **Fitzpatrick, H. M.** The summer foray 277; The Seventh Lake Foray 377

Drayton, F. L. The sexual mechanism of *Sclerotinia Gladioli* 46

Drechsler, Charles. A new species of *Helicocephalum* 33; Organs of capture in some fungi preying on nematodes 135

Fitzpatrick, H. M. The Mycological Society of America 108; Report of the second annual meeting 197

——, **Dodge, B. O.** & **Stewart, F. C.** The summer foray 277; The Seventh Lake Foray 377

Hahn, G. G. & **Ayers, T. T.** Dasyscyphae on conifers in North America. I. The large-spored, white-excipled species 73; II. *D. Ellisiana* 167; III. *Dasyscypha Pini* 479

Hedrick, Joyce. New genera and species of lichens from the herbarium of Bruce Fink. II 153

Hesler, L. R. Report of the Highlands Foray 195

Hotson, J. W. Mushroom poisoning at Seattle 194

—— & **Lewis, Esther.** *Amanita pantherina* of western Washington 384

Jenkins, W. A. The development of *Cordyceps agariciformia* 220

Jones, L. R. Arthur Bliss Seymour 279

Karling, J. S. A saprophytic species of *Catenaria* isolated from roots of *Panicum variegatum* 528

Kevorkian, A. G. The structure and development of a new aquatic Phycomycete 145

Kienholz, J. R. A poisonous *Boletus* from Oregon 275

Lange, J. E. Mycofloristic impressions of a European mycologist in America 1

Latham, D. H. Life history of a *Cercospora* leaf spot fungus of cowpea 516

Lewis, Esther & **Hotson, J. W.** *Amanita pantherina* of western Washington 384

Linder, D. H. The genus *Myxomycidium* 332; North American Hyphomycetes II. New species and a new genus 436

Mains, E. B. *Angiopsora*, a new genus of rusts on grasses 122

Martin, G. W. Three new Heterobasidiomycetes 261

McCrea, Adelia. Fungicidal value of some common dyes against dermatophytic fungi 449; Longevity of *Merulius lacrymans* in wood destroyed by its growth 454
Miller, L. W. The Hydnaceae of Iowa. II. The genus *Odontia* 13; III. The genera *Radulum, Mucronella, Caldesiella* and *Gloiodon* 212
Müller, A. S. A note on mycology in Brazil today 192
Orton, C. R. Manual of the rusts in United States and Canada 469
Overholts, L. O. Mycological notes for 1933 502
Reneger, C. A. & **Waksman, S. A.** Artificial manure for mushroom production 38
Seaver, F. J. Photographs and descriptions of cup-fungi—XX. A new *Lamprospora* 102; Another rare phalloid 273; XXI. The genus *Calycina* 344
Shear, C. L. *Penicillium glaucum* of Brefeld (*Carpenteles* of Langeron) refound 104; Mycology, scientific and otherwise 201
Shimek, B. Thomas Huston Macbride 379
Smith, A. H. Investigations of two-spored forms in the genus *Mycena* 305
Snell, W. H. Notes on Boletes. III 348
Stevens, N. E. Mycological letters from M. A. Curtis 1856–1861 441
Stevenson, J. A. Obituary 477
Stewart, F. C., Fitzpatrick, H. M. & **Dodge, B. O.** The summer foray 277; The Seventh Lake Foray 377
Swartz, Delbert. *Pilobolus crystallinus* in pure culture 192
Thompson, G. E. Sporangial germination in the genus *Myxocytium* 118
Togashi, K. & **Zeller, S. M.** The American and Japanese Matsu-takes 544
Voorhees, R. K. *Rhopographus Zeae* on corn 115
Waksman, S. A. & **Reneger, C. A.** Artificial manure for mushroom production 38
Whelden, R. M. Cytological studies in the Tremellaceae I. *Tremella* 415
Wolf, F. A. William H. Weston, Jr., first president of the Mycological Society of America 113
Zeller, S. M. A new species of *Lepiota* 210; Some new or noteworthy fungi on ericaceous hosts in the Pacific northwest 291
—— & **Togashi, K.** The American and Japanese Matsu-takes 544

INDEX TO GENERA AND SPECIES

New names and the final members of new combinations are in **bold face type.** Mistakes in the spelling of scientific names encountered in text are corrected in the index.

Abrothallus 287
Acarospora Heppii 159; **immersa** 158; **saxicola** 159; Scheicheri 159
Achorion 451
Achroomyces *262*; pubescens *262*
Acia ferruginea 216; fuscoatra 30; membranacea 30; tomentosa 217; uda 31
Actinomyces 450
Aecidium 475
Agaricus 4, 12, 192, 380; abruptibulba 4; arvensis 4; arvensis abrupta 4; campestris 4, 45; campestris silvicola 4; magnivelaris 550; ponderosus 550
Aleurodiscus 508; amorphus 81, 508; apiculatus 196, 508
Alternaria 504
Amanita 384; bisporigera 8, 330; Caesarea 11; cothurnata 259, 260, 386; flavoconia 12; muscaria 8, 276, 387; muscaria americana 8; muscaria umbrina 386; pantherina 194, 195, 259, 260, 384–388, 390, 391; pantherinoides 384–386, 390; phalloides 8; solitaria 11; spreta parva 197; verna 8; virosa 8
Angiopsora 126, 128–131; compressa 129, 132; **lenticularis** 126–129, 132; **pallescens** 128, 132; **phakopsoroides** 128, 132
Annularia Fenzlii 255; pusilla 255
Anthurus borealis 274, 275
Anulosporium 135; nematogenum 135, 138
Apioporthe 273; Corni 273

Araiospora 145, 147, 148, 150, 152; coronata 145, 148, 151, 152; pulchra 145, 148–152; spinosa 145, 147, 150, 151; **streptandra** 147, 150, 151
Arcyria pomiformis 196
Armillaria 544, 549; arenicola 549, 550, 556; caligata 548, 549; corticata 197; denigrata 10; edodes 545; magnivelaris 550, 552, 556; matsutake 544–546, 548, 549, 553, 554, 556, 558; ponderosa 549–558; robusta 551
Arthrobotrys 138, 141, 142; oligospora 137, 139–141
Ascobolus 242, 251, 372, 437; citrinus 230; furfuraceus 250; stercorarius 251
Ascochyta lethalis 502
Aspergillus 107, 252, 360; niger 451, 452

Badhamia 287
Balansia Hypoxylon 196
Biatora 156
Bilimbia sphaeroides 156; **Pammellii** 156; epixanthoides 156
Blastenia lobulata 164; modesta 164; **novomexicana** 163
Boletinus pictus 12
Boletus 192, 253, 275, 276; albellus 349, 350; albidipes 352; americanus 353; Atkinsoni 356; aurantiacus 350, 351, 352, 359; auripes 356; Betulae 509; bovinus 6, 548, 549; brevipes 353; carolinensis 356, 357; castaneus 358; chromapes 349, 350; Curtisii 356, 357, 358; cyanescens 197, 358; decorus 355; Eastwoodiae 276; edulis 354, 355, 356, 551; elbensis 350; elegans 6, 549; eximius 355; felleus 348; flaviporus 352; floccopodus 350, 351, 352; floccopus 350; granulatus 352–354; hirtellus 353; inflexus 353; laricinus 350; leucophaeus 350–352, 359; limatulus 355; mutabilis 348, 349; niveus 349–352, 359; nobilis 356; parasiticus 197; Peckii 349; placidus 353; porphyrosporus 348; pulverulentus 348, 349; punctipes 353, 354; roseotinctus 349; rubropunctus 353; rufus 350; rugosus 350; Russellii 509; satanas 276; scaber 349–352, 359; separans 355, 356; sordidus 348; subalbellus 358; subaureus 353, 354; subglabripes 349; subpunctipes 349; variipes 356; versipellis 349, 350–352, 359; viscidus 350
Bombardia fasciculata 196
Bonordeniella 439; **aspera** 439, 440; memoranda 439
Botryobasidium 196
Botryodea 509
Botrytis 47, 67, 68, 360, 436; cinerea 71
Bubakia 122, 124–126, 130, 131; Crotonis 125, 126

Caeoma 475
Caldesiella 216; crinalis 217; ferruginosa 216, 219
Calicium polyporaeum 196
Caloplaca citrina 163; **oxfordensis** 162; sideritis 163
Calycina 344, 345; **bolaris** 345–347; firma 345, 346; **macrospora** 345–347
Camarophyllus virgineus 313, 323, 330
Cantharellus 330; floccosus 197, 549; infundibuliformis 197; tubaeformis 197
Carpenteles 106; **asperum** 105–107; **brefeldianum** 107; glaucum 107; **javanicum** 107
Catacauma biguttulatum 461
Catenaria 528–530, 532, 537–540; Anguillulae 528, 530, 532, 535–542
Causalis 465; Myrtacearum 465
Cenangella Rhododendri 291
Cenangium 271; Ribis 268
Cephalothecium 138, 141; roseum 141
Cercospora 504, 520, 523–525, 527; cruenta 516, 518, 525–527; Menispermi 502
Ceriomyces 254; crassus 354
Cerotelium 129
Chaetobasidiella vermicularioides 207
Chamaeota 254, 255; Fenzlii 256; mammillata 255, 256; pusilla 254–256, 259; sphaerospora 255
Chondropodium Urceolus 268
Chrysomyxa Piperiana 294
Chytridium zoötocum 542
Ciboria 344, 345; bolaris 346; Dallasiana 346; firma 345; fuscocinerea 346; ochroleuca 345
Cladochytrium 539–542; replicatum 528
Cladonia cristatella **densissima** 157; degenerans lepidota 158; furcata racemosa 158; gracilescens 158; **Herrei** 157; rangiformis 158; subsquamosa 158
Clasterosporium 116; **longisporum** 117; maydicum 116; olivaceum 116; Zeae 116

Clavaria 321, 324, 330, 332, 337; botrytis 338; cristata 196
Claviceps 223; microcephala 223; purpurea 223, 240, 241
Clitocybe illudens 12
Clitopilus abortivus 12, 197
Clypeotrabutia 464, 465; portoricensis 465
Coccophacidium crustaceum 501
Collema **fayettense** 153; plicatile 154; pustulatum **heterosporum** 154
Collybia clusilis 314; myriadeophylla 12
Colus javanicus 275; Schellenbergiae 273
Coniophora vaga 509, 510
Coniothyrium Rhododendri 304
Coprinus 71; ephemerus 321
Cordyceps 220, 222, 223, 231, 241; agariciformia 220, 221, 223, 224, 226–228, 233, 235, 238, 240–242; clavulata 196, 223, 224; militaris 222, 224–228, 230–236, 242; norvegica 222; ophioglossoides 222, 234, 241; parasitica 220, 222; Sphingum 242
Cornularia macrospora 502, 515
Corticium 212, 436, 437, 509, 510, 513; amorphum 81; **botryoideum** 509, 510, 515; byssinum 196; colliculosum 212; confusum 196; coronatum 196; **fenestratum** 509, 510, 515; hydnans 213; myxosporum 19; roseum 508; subcoronatum 196, 509, 510, 515; tulasnelloideum 196; vagum 509–511, 515
Cortinarius cinnamomeus 548; elatior 548; largus 197
Cortinellus 558; Berkeleyanus 545
Coryneum 302, 303; Rhododendri 302
Craterellus 321, 324, 330; Cantharellus 12
Crepidotus stipitatus 197
Cribraria microcarpa 196
Cronartium 129; ribicola 497
Crumenula 271
Cryptodiaporthe 273; Macounii 273
Cryptostictis 301, 302; Arbuti 300, 302, 304; Mariae 302, 304
Cyphella caricina 511, 515

Dacryobolus sudans 23
Dacryomitra 263; **brunnea** 263, 265
Dacryopsis 263
Dactylaria 137, 138, 141, 142, 437; candida 136–138, 141, 437, 438; echinocephala 438; graminum 438; mucronulata 438; oogena 438; oogena Pancierii 438; Orchidis 437, 438; parasitans 438; **pulchra** 438, 440; purpurella 438; simplex 438
Dactylella 138, 141; ellipsospora 139, 141
Dactylium 138; candidum 136
Dasyscypha 73–77, 81, 87, 88, 92, 94, 95, 98, 101, 167, 168, 172, 174, 175, 177, 480–482, 493, 494, 498–500; arida 485, 486, 493, 497; bicolor 74, 75; calyciformis 74, 76, 80, 82, 175; calycina 73–77, 79, 80, 82–88, 92, 94–99, 167, 168, 483, 497–499; calycina minor 83; cerina 75, 174; Ellisiana 74, 167–180, 479, 500; Ellisii 169, 171; flavovirens 486, 497; fuscosanguinea 74, 479–487, 490, 493, 494, 497, 498, 500, 501; fuscosanguinea aurantiaca 484, 486; Gaultheriae 292; lachnoderma 168, 169, 171–173, 176, 178, 179; monticola 487, 491; **oblongospora** 88, 89, 93, 94, 98, 100; **occidentalis** 84, 90, 91, 93, 96, 98, 100; **Pini** 487, 491–499, 501; resinaria 74, 177; virginella 293; Willkommii 74, 77, 79, 80, 82–88, 93–101, 167, 177, 479–481, 483, 488, 491, 493, 497, 499
Dermatea **brunneopruinosa** 291, 292, 303
Diachora 465, 468; Onobrychidis 461, 462
Diaporthe 273; Bakeri 273; dakotensis 273; Fagi 273; Hickoriae 273; Opuli 273
Diaporthella 273
Diaporthopsis appendiculata 273
Dicaeoma 131; pallescens 128; phakopsoroides 128
Dictyuchus 411, 414
Didymosporium 303; **arbuticola** 303, 304
Dimerosporium balsamicola 503, 505, 506
Diplocarpon Rosae 187
Diplocladium 503; penicillioides 503, 515
Diplodina Eurhododendri 291
Diplophlyctis 537; intestina 542
Dipodascus 61
Disaeta 301; Arbuti 300

Echinostelium minutum 196
Ectotrichophyton mentagrophytes 207
Elaphomyces 220–224, 238
Elsinoe 300
Elvela atra 196
Endothia parasitica 497
Entoloma salmoneum 12; strictius 12

Entophlyctis 537, 542
Entyloma arnicale 507
Epichloe Bambusae 230, 241; typhina 230, 231
Epidermophyton 451; rubrum 450–452
Eremascus 61
Erysiphe Mors-uvae 2
Eurotium 107
Exidia 415–417, 427–430, 432; glandulosa 416; saccharina 415, 416; truncata 416
Exobasidium 295–297; **Burtii** 294, 295, 298; Ledi 297; Parvifolii 297; Vaccinii 295–298; Vaccinii-uliginosi 296–299

Fomes Arctostaphyli 299–301; igniarius 300
Fuckelia Ribis 267
Fusarium 137, 138, 450, 452, 453

Galera 324; silignea 324; tenera 322
Geaster minimus 383
Geopyxis 344; nebulosa 344, 346
Gloiodon 217; fimbriatus 17; stratosus 218; strigosus 218, 219
Glomerella 360
Godronia 267–269; Andromedae 270; **Davidsoni** 269; Urceolus 266–270; Urceolus Betulae 267
Godroniopsis quernea 506
Gomphidius roseus 6; viscidus 6
Gonapodya 118
Gonatobotryum maculicola 196
Grandinia Agardhii 23; crustosa 28; exsudans 23; granulosa 28; sudans 23
Gymnosporangium 181, 187, 188, 475; Botryapites 187; Ellisii 181; fraternum 187; germinale 185; juniperinum 181, 182, 188; Juniperi-virginianae 188; myricatum 181–183, 185, 187, 188, 189

Helicocephalum 33, 36; **oligosporum** 35–37; sarcophilum 33–35
Helicomyces 135
Helicoon 135
Helminthosporium 360
Helotium Ellisianum 169; firmum 345; macrosporum 344, 346
Helvella 192
Heterochaetella 262
Heterosporium Allii 503
Humaria granulata 69
Hydnum Agardhii 22, 23; alutaceum 21, 22; argutum 26; Barba-Jovis 23; bicolor 27; carbonarium 30, 31; caryophylleum 27; ciliolatum 18; crinale 216, 217; crustosum 28; echinosporum 27; fagineum 213; fasciculare 19; ferrugineum 216; ferruginosum 216; fimbriatum 17; fuscoatrum 30; granulosum albicans 22; nudum 28; Nyssae 23, 24; pallidum 26; quercinum 213; Radula 212; serratum 27, 28; spathulatum 25; stipatum 24; stratosum 218, 219; strigosum 218; subtile 27, 28; sudans 22, 23; tabacinum 216, 217; udum 31
Hygrophorus conicus 330
Hymenobolina parasitica 196
Hymenoscypha bolaris 346; firma 345
Hyphochytrium infestans 540
Hypholoma fasciculare 6
Hypocrea alutacea 240
Hypoxylon 202; regale 196; serpens macrospora 196
Hysterographium Fraxini 93

Inocybe agglutinata 197; decipientoides 197; geophylla 6; leptocystis 197; prominens 197; umbrinella 197
Irpex 26; pachyodon 219; spathulatus 25

Kneiffia irpicoides 23, 24; setigera 19; stenospora 21

Laccaria laccata 6; ochropurpurea 12
Lachnea scutellata 241
Lachnella 493, 499; confusa 484, 485; fuscosanguinea 481, 484, 500; Pini 481, 484, 487, 498, 500
Lachnellula chrysophthalma 498, 499
Lachnum 74, 75, 173, 174, 178, 179, 292, 293; echinulatum 292, 293; **Gaultheriae** 292, 293, 304; **lachnoderma** 173, 174, 176, 178, 179; **virginellum** 293
Lactarius 8; atroviridis 197; deceptivus 9; deliciosus 5, 9; griseus 7; mucidus 197; Peckii 197; piperatus 9; repraesentaneus 8, 11; scrobiculatus 8; subpurpureus 9, 11
Lagenidium americanum 121
Lamprospora 102; **sphagnicola** 102; trachycarpa 102
Leaia piperata 218; stratosa 218
Lecanora **bipruinosa** 160; calcarea 162; dispersa 162; **iowensis** 161; muralis 160; pallida **prolifera** 161; Sambuci **minnesotensis** 161
Lecidea 156; **congesta** 155; sylvicola 156
Lentinus 11; haematopus 511, 512; variabilis 330

Lepiota 9; **Barssii** 210, 211; brunnea 512, 515; clypeolaria 9; cygnea 12; naucina 210, 211; rhacodes 512
Leptogium **perminutum** 154; rhyparodes 155; Schraderi 155; tenuissimum 155
Leptolegnia caudata 241
Leptomitus 118
Leptonia lampropoda 197; subserrulata 197
Leptosphaeria Gaultheriae 293
Leptostromella filicina 503
Leptothyrium Periclymeni 504, 515
Limacium hypothejus 6
Lophodermium melaleucum **epiphyllum** 293; Oxycocci 293
Lycoperdon 475

Macbridella 381
Marasmius 11; pulcheripes 12; siccus 12
Mastomyces 268; Friesii 267, 268; uberiformis 267–269
Melampsora 475
Melanospora Pampeana 251
Melasmia acerina 458; arbuticola 294; Menziesiae 303
Meliola circinans 468
Merulius 455; americanus 454; lacrymans 454, 455
Methysterostomella argentinensis 207
Microascus trigonosporus 461
Microsporum 451
Monacrosporium 137, 138, 141, 142; elegans 137; subtile 137
Monilia 251, 252, 375
Monochaetia 505
Monosporidium repens 139, 141
Mortierella 33
Mucronella 214; abnormis 215; aggregata 215, 219; calva 215; minutissima 215; ramosa 215; Ulmi 215, 216, 219
Mycena 9, 257, 305, 306, 309, 319, 320, 322–324, 326; alcalina 306, 309, 313, 316, 325, 326; Atkinsoni 306, 310, 325, 326; aurantidisca 12; capillaris 306, 308, 309, 313, 316, 320, 325, 326, 329; **cholea** 306, 313, 316, 325, 329; citrinomarginata 306, 308, 309, 313, 318–320, 325, 326, 329; clavicularis 306, 309, 311, 313, 325, 328; debilis 322; dissiliens 307–309, 313, 318, 325, 329; epipterygia 309, 326; galericulata 321; **glutinosa** 257; graveolens 306, 309, 311, 313, 328; haematopoda 306, 321, 325; hemisphaerica 306, 325, 327; immaculata 306, 309, 311, 313, 325, 326, 328; lactea 309, 326; lasiosperma 307, 313, 316, 318, 325, 329; Leaiana 12; leptocephala 306–309, 313, 318, 325, 329; margaritispora 307, 311, 313, 318, 325, 328; megaspora 307, 313, 314, 316, 319, 323, 325, 326, 328; metata 307, 309, 311, 313, 315, 319, 321, 323, 325–327; mirata 307, 325, 326, 328; murina 306, 310, 325, 327; pelianthina 9; polygramma albida 307–309, 313, 316, 319, 325, 329; **pseudopelianthina** 9, 11; roseipallens 307, 309, 313, 316, 325, 326, 329; rubromarginata **Laricis** 307, 313, 316, 325, 329; sanguinolenta 306, 325, 328; stannea 306, 325, 328; supina 309; viscosa 306, 307, 309–311, 313, 325–328; vitilis 307, 313, 316, 325, 329
Mycoleptodon 18; fimbriatum 17; strigosum 218
Mycosphaerella 525; arbuticola 293, 304; Bolleana 520, 527; cerasella 520, 527; Chimaphilae 293; chimaphilina 293; **cruenta** 525, 526; Gaultheriae 294; Impatientis 506; personata 527; Thalictri 506
Mycotypha microspora 133
Myxomycidium 332, 336–338; **guianense** 339–342; **nodosum** 339–342; pendulum 339, 341, 342
Myzocytium 118, 119; proliferum 119–121; vermicola 119–121

Naematelia 196
Naucoria lenticeps 324; semiorbicularis 322; semiorbicularis bispora 320
Nectria galligena 240
Neurospora 248, 250, 251, 252, 360–362, 368, 369, 371, 372, 374, 375, 410, 414; crassa 370, 373; sitophila 244, 248, 251, 360, 361, 374; tetrasperma 361–363, 368–370, 374–376, 410
Nidularia 330
Nolanea cetrata 322

Ocellaria aurea 506, 515
Odontia 13, 17, 18, 20, 22, 26, 29; acerina 19; alutacea 14, 21, 26, 27, 32; arguta 14, 21, 25–27, 32; Barba-Jovis 15, 23, 24, 32, 216; bicolor, 14, 27, 32; **ciliolata** 14, 18, 19, 32; conspersa 15, 16; corrugata 30; crinalis 217; cristulata 14, 20, 21, 32, 196; crustosa 14, 28, 29, 32; **crustula** 14, 28, 29, 32; farinacea 16; ferruginea 217; fimbriata 14, 17–19, 32; fuscoatra

15, 30, 31, 32; glauca 16; granulata 20; hydnoides 13, 15–17, 32; junquillea 30; **laxa** 14, 18, 19, 32; livida 14, 29, 32; membranacea 30, 31; Queletii 13, 15–17, 32; **setigera** 13, 19–21, 32; stipata 15, 24, 25, 32; subalbicans 14, 22, 32; subtilis 27; sudans 14, 22, 23, 32; uda 15, 30–32
Oedocephalum 437
Oidium 475
Olpidium 532, 533, 536; endogenum 536; gregarium 536
Omphalia 257, 305
Ophiobolus graminis 230, 233, 241
Ophiodothella 456, 463–467; **Vaccinii** 458, 459, 461–463, 465, 467
Ophiodothis atromaculans 464, 468
Oxydontia stenodon 15

Panus 512; anisatus 512; laevis 197; stipticus 10
Parmelia carolinana 162; **Finkii** 162; latissima 162
Peckiella lateritia 241
Penicillium 104; Brefeldianum 105, 107; glaucum 104, 106, 107; javanicum 107
Peniophora 20, 436; albugo 514; attenuata 196; crassa 513, 514; crystallina 15, 16; **delectans** 513–515; **dissoluta** 514, 515; glebulosa 513, 514; hydnoides 15, 16; pallidula 196; pilosa 514; setigera 19; subalutacea 513
Pertusaria lecanina **nigra** 160
Pestalozzia 446; campsosperma 505; gibbosa 292, 303
Peziza 61, 75, 80–82, 168, 172, 481; bolaris 346; calycina 76, 77, 81, 82, 97, 99, 167–169, 171, 177, 179, 483; domiciliana 463, 468; Ellisiana 168, 169, 171, 172, 174, 179; firma 344, 345; Gaultheriae 292; lachnoderma 168, 169, 171–174, 176, 179; melanopus 176, 178; nebulosa 346; ochroleuca 345; vesiculosa 61; virginella 293; Willkommii 81, 82, 84–86, 101
Phacidium Gaultheriae 294; infestans 491; Vaccinii 294
Phaeodon tomentosus 216
Phaeomarsonia 303
Phakopsora 122–124, 126, 130, 131; punctiformis 124, 126
Phialea bolaris 346; firma 345
Pholiota aggericola 10; albocrenulata 12; erebia 10, 322; erinacella 12; indecens 10
Phoma 446
Phragmidium 475
Phyllachora 465
Phyllactinia corylea 459, 462
Phyllosticta Liriodendri 504; macrospora 504; Rhodorae 304
Physarum 382
Physoderma 539, 541; Zeae-Maydis 534, 542
Phytophthora 186, 450; infestans 2
Pilobolus crystallinus 192–194
Pistillaria 513; abietina 512
Platygloea 262; **sphaerospora** 261, 265
Pleurage anserina 47, 71, 392–396, 398, 400–402, 405, 407–411, 413, 414
Pleurotus 10, 197, 503; applicatus 10; atropellitis 197; Rhacodium 7, 10, 11
Plowrightia morbosa 383
Pluteus 9, 256, 257; admirabilis 10, 257; caloceps 9, 11, 256; coccineus 256, 257; leoninus 10, 256, 257; leoninus coccineus 10, 256; sororiatus 257
Podospora anserina 393, 414
Polyporus balsameus 196; fragilis 196; graveolens 196; Montagnei 196; Pes-caprae 196; poculus 197; retipes 197
Polystigma rubrum 230, 240, 241, 458, 459, 461
Poronia punctata 458
Porothelium confusum 23; Stevensoni 23
Protohydnum lividum 417
Psalliota 4; arvensis 4; campestris 322, 331; silvicola 4
Pseudopeziza autumnalis 507
Puccinia 108, 122–124, 127, 128, 130, 131; Acetosae 196; compressa 122–124, 129; Elymi 124; heterospora 289; longipedicellata 108; Malvacearum 2; pallescens 122–124, 128; parca 507; parnassiaecola 108; phakopsoroides 122–124, 128, 129; rubigo-vera 124; tenuis 507; Veronicarum 473
Pucciniastrum americanum 508; Hydrangeae 508
Pustularia bolarioides 232, 240
Pyronema confluens 241, 459, 461
Pythium 33, 143, 152; mastophorum 149

Radulum 25, 212, 214; fagineum 213; hydnans 212; orbiculare 212–214, 219; pallidum 212–214, 219; quercinum 212–214, 219; spathulatum 15, 25, 26, 32
Ramularia arnicalis 507; Delphinii

505; sambucina 504, 505; Sheldoni 505
Rhipidium 152; europaeum 147; spinosum 145
Rhizina undulata 230, 241
Rhizopogon occidentalis 551; rubescens 549, 551
Rhizopus 68, 252; nigricans 244
Rhopographus 115, 116; Zeae 115, 116
Rhytisma 463; acerinum 236, 241, 468; Arbuti 294; punctatum 463; Vaccinii 463, 466
Rinodina **bolodes** 165; Conradi 165; **kentuckyensis** 164; microbola 164; nigra 164; **ochrocea** 165; sophodes 166; turfacea 165
Roestelia Botryapites 187
Rosellinia Clavariae 196
Russula 258; aeruginea 197; compacta 12; delica 551; **heterospora** 259; variata 258, 259; ventricosipes 258
Rutstroemia firma 345

Salmonella pullorum 453
Sapromyces 148, 152
Scherffelia 377
Scherffeliomyces 377
Schizoparme straminea 458
Schizospora 131
Schroeteriaster 122, 124–126, 130, 131; alpinus 125
Scleroderris 268, 271; ribesia 267–270; **tumoricola** 269, 270
Sclerodon strigosus 218
Sclerotinia 47, 48, 53, 56, 61, 66–68, 70, 72; Duriaeana 72; Fuckeliana 61, 71; Gladioli 46, 47, 52, 61, 62, 65–69; longisclerotialis 72; Ricini 67; sclerotiorum 67, 71
Sclerotium 47, 67; Gladioli 46, 69
Scolecodothis 464; hypophylla 464
Scolecodothopsis 464, 465; Ingae 464, 468
Scoleconectria scolecospora 196
Scopulariopsis 467
Sebacina 262, 417, 429; gloeocystidiata 417; **sublilacina** 262, 263, 265
Sepedonium brunneum 196
Septobasidium pinicola 196
Septoria 304, 446; increscens 505; Mimuli 505; solitaria 304
Sistotrema fagineum 213; Radula 212
Solenia fasciculata 197
Sommerstorffia spinosa 144
Sordaria macrospora 370, 373
Sphaerella Bolleana 459
Sphaeria 242, 475
Sphaerobolus 273
Sphaeropsis 446
Spondylocladiella 437; **botrytioides** 437, 440
Spondylocladium 436
Sporobolomyces 273
Sporodinia 68
Sporotrichum 450
Steccherinum lacticolor 13; ochraceum 13, 17; setulosum 13; strigosum 218
Steganosporium acerinum 505; piriforme 505
Stereum Burtianum 196; Murrayi 196; pallidum 196
Stigmatea Pyrolae 293
Strobilomyces strobilaceus 350
Stropharia depilata 11; psathyroides 12
Syncephalis 33
Synchytrium 532, 533
Synechoblastus laciniatus 153; **wyomingensis** 153

Tarzetta cinerascens 346
Thelebolus lignicola 196; sudans 22
Thelephora albidobrunnea 196; setigera 19
Thielavia basicola 251
Tilletia Tritici 273
Toxosporium abietinum 196, 505
Tremella 264, 415, 417–420, 422, 424–430, 432, 433, 475; aurantia 196; foliacea 416; frondosa 419–421, 423, 425, 427, 429, 431, 434; gemmata 417; Genistae 428; glacialis 419, 420, 428; Grilletii 419–421, 423–429, 431, 435; indecorata 417; lutescens 416, 419, 428; mesenterica 416, 419, 421–425, 427–429, 431, 433
Tremellodendron Cladonia 196
Tricholoma 305; decorosum 197; equestre 551; leucocephaloides 197; portentosum centrale 197; psammopodum 6; subsejunctum 197; transmutans 197
Trichomanes Petersii 289
Trichopeziza fuscosanguinea 484
Trichophyton 450, 451; interdigitale 451, 452
Trichoscypha 75
Trichoscyphella 75, 494; Willkommii 75, 84
Trichothecium 138, 142; roseum 141, 144
Tulasnella 264
Tylopilus 254; **conicus** 253, 254

Ulocolla 415
Uredo 128, 474, 475, 476; Chardoni 108; pallida 123, 128

Uromyces 108, 126, 130, 131; alpinus 131; leptodermus 122
Urophlyctis 539, 540; Alfalfae 542

Venenarius pantherinoides 384, 391
Volvaria pubescentipes 12

Vuilleminia 337, 338; comedans 337

Xylaria 202; ianthinovelutina 196

Zoophagus insidians 143, 144